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The Pricing of Water in Louisiana.

Roopchand Ramgolam
Louisiana State University and Agricultural & Mechanical College

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by
Roopchand Ramgolam
B. A., Inter-American University of Puerto Rico, 1964
M. S., University of Puerto Rico, 1966
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ABSTRACT

In Louisiana, the primary water problem is one of proper allocation of water among residential, industrial and agricultural users. In this context, this study evaluates current price structures and pricing policies in order to explore the use of economic criteria for an efficient allocation of the resource.

Data collected pertained to the organization of water supplying units, their production and distribution systems, price schedules, bases of price determination, and the financial status of each unit. To put this study into perspective, the role of price theory in allocation of water resources was examined and a review of water pricing policies in arid and humid regions of the United States was accomplished.

Residential water supplies in Louisiana are provided by regulated water utilities owned by private investors, municipal governments, or by groups of individuals organized to form nonprofit corporations whose investment funds are provided by the Farmers Home Administration. A comparative analysis indicated that FHA sponsored water utilities charged \$10.08 for 10,000 gallons of water while private and municipal utilities charged \$7.90 and \$6.74, respectively. Average annual operating costs per capita was \$13.37 for municipal water utilities, \$16.63 for FHA water utilities, and \$17.74 for private water utilities.

Of the 231 water utilities surveyed, 71 percent had a metered rate system based on declining block rates, and the greater discounts in price were given by municipal water utilities. Most water utilities considered the first block as constituting the minimum monthly charge.

Regression analysis between population served and total annual operating cost revealed a positive linear relationship between these two variables, particularly in the nature of ownership of water utilities. The level of these costs in relation to income resulted in one out of three water utilities incurring a net loss in 1971. Losses were more frequent among private water utilities where the use of flat rates was most common. Special charges included rates for fire protection, outside-limits customers, tapping fee, customer deposits, meter installation, reconnection fees, air-conditioning and lawn-sprinkling. These special charges and water rates were all based on the average cost of the service.

Water used in agriculture in Louisiana is primarily for the production of rice and is either self-supplied or provided by canal companies. The cost for water from a canal company is generally based on a proportion of the rice crop. A comparative analysis between a subsurface pipeline and a surface canal to irrigate a 136.5 acre rice farm was made. The price of water by canal companies ranged from \$4.80 to \$13.45 per acre-foot while the range was \$3.61 to \$8.90 for a self-supplied system.

The supply of water for industry is predominantly self-supplied and once the water system is established, costs relate only to pumping and transmission. A local chemical plant estimated costs at \$0.08 per

1,000 gallons and a metal products firm between $0.10 to $0.17 per 1,000 gallons of water.

In view of the diversity of pricing policies and the tendency to average-cost pricing by water utilities, it is recommended that a marginal-cost pricing policy be applied for more efficient allocation of water. A service charge equal to the semi-fixed marginal costs and a per unit charge equivalent to the seasonal variable marginal costs constitutes the basic rate proposal. A property tax or an increase in the service charge could be used to finance the income deficit in systems with decreasing average costs of production. For industry and self-supplied agricultural users, the assignment of water rights or quotas, or the imposition of a "use-tax" consistent with the divergence between marginal social and private costs was recommended.

CHAPTER I

INTRODUCTION

"Water is the best of all things," said the Greek poet Pindar, however, the most remarkable thing about water is how few realize how remarkable it is. As our single most valuable natural resource, its occurrence, availability, and use, affect every living thing. As a consequence, the survival of man, physically, economically, and socially, depends on adequate amounts of water of an accepted quality. With our rapidly increasing population and attendant growth in agriculture and industry -- the largest water users -- water will continue to play a strategic role in the development of civilization, the localization of towns, the establishment of industries and the settlement of populations. A vivid demonstration of this role is exhibited in the location and growth of the capital city of Louisiana, Baton Rouge, whose origin and development is closely associated with America's greatest waterway -- the Mississippi River. Generally, the growth or economic development of any area is governed by the availability of water. Through the ages, man has been concerned with variable supplies of water arising largely from the uneven distribution of rainfall. More recently, increasing demands for this resource, whose immediate supply is limited, make the problem more acute.

In our capitalistic system, the pricing mechanism is the primary agent for allocating scarce resources capable of alternative uses. However, the functioning of this economic mechanism has never been fully utilized in allocating water supplies, mainly because society considered this good as cost free and "valueless". Plato, who first offered a systematic exposition of the principles of society noted, "That which is scarce is valuable. Water is not valued, althouth the most useful thing in the world."[1] Adam Smith, generally regarded as the founder of clasical economic thought, carried forward the same line of reasoning by stating, "Nothing is more useful than water . . . but it will purchase scarce anything; scarce anything can be had in exchange for it."[2] David Ricardo, in the opening paragraph of his major work, dealt not only with water but air also.[3] Considered as free goods, with high use value, but practically no exchange value, society will always resist pricing or price increases for water resources. Such an attitude is further sustained by society when considering water required for life and public health consideration. As competition for water intensifies this conceptual framework will have to be radically

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[1]Eric Roll, A History of Economic Thought, (Englewood, New Jersey: Prentice Hall, Inc.) 1956, p. 27.

[2]Adam Smith, An Enquiry Into the Nature and Causes of the Wealth of Nations, (New York: The Modern Library, Random House), 1937, p. 28.

[3]David Ricardo, The Principles of Political Economy and Taxation, (New York: E.P. Dutton and Co.), 1957, p. 5.

changed and indications of such changes are currently evident on a large scale in the United States, where the demand for water has reached enormous dimensions.

In this respect, the Office of Water Resources Research of the United States Department of the Interior had this to say:

> The United States appetite for water is voracious. On all sides, the mounting demands are insistent and relentless. Municipalities, industries, recreation, agriculture, and other uses are asking for more and more. Daily consumption is expected to double, approximately within 15 years --- if water is available.[4]

Conceptually, this sounds rather ominous when one takes into consideration that to produce a pound of dry wheat some 60 gallons of water are required; a pound of rice uses 200-250 gallons; a pound of meat 2,500-6,000 gallons; a quart of milk about 1,000 gallons; a single automobile an estimated 100,000 gallons.[5]

The share of all water utilized by each American in 1900 was approximately 525 gallons daily. By 1960, this level of consumption had increased to 1,500 gallons and it is expected to reach 2,000 gallons by 1980.[6] Conservative estimates of projected water requirements in the United States in 1980, according to Picton, will be about

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[4]United States Department of the Interior, Cooperative Water Resources Research and Training, 1965 Annual Report, (Washington, D. C.: United States Government Printing Office), 1965, p. xi.

[5]Paul R. Erlich and Anne H. Erlich, Population, Resources, and the Environment, First Edition, (San Francisco: W. H. Freeman and Co.), 1970, p. 64.

[6]Ibid., p. 65.

502.2 billion gallons a day. However, Erlich, on a more liberal note, prognosticated 700 billion gallons a day and believes that by 1980 a water shortage is inevitable. Even with the most optimistic technological and economic assumptions, he emphasized, only an estimated 650 billion gallons can be made available.[7]

No challenge can fully defy Erlich's predictions because with current changes in population numbers and distribution, urbanization, pollution, and industrial and agricultural expansion, it is expected that competition for water will continue to mount in future years. In 1970, total water use for the nation amounted to 327.3 billion gallons per day (bgd) with irrigation utilizing 119.8 bgd, industries using 176.75 bgd, residential water supplies accounting for 27.03 bgd, and others 3.7 bgd. By 1980, these uses are estimated to reach 178 bgd, 237 bgd, 82 bgd, and 52 bgd, respectively (Table 1).

In Louisiana, the water situation appears less foreboding than for the nation as a whole since the state enjoys an average annual rainfall of 50 to 60 inches and water is regarded as a relatively abundant resource. Apart from this, however, the uneven distribution of water supplies results in periodic floods and minor droughts. With increasing population and agricultural, industrial, and metropolitan growth, these problems undoubtedly will become more serious in the coming years.

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[7] Ibid, p. 65.

Table 1. Estimates of Total Water Use in the United States 1970 and 1980

Water use	1970 1/	1980 2/
	- - - Billion gallons per day - - - -	
Irrigation	119.8	178.0
Industry	176.8	237.0
Residential	27.0	82.0
Other	3.7	5.2
Total	329.3	502.2

1/ United States Bureau of the Census, Statistical Abstract of the United States, 92nd Edition, (Washington, D. C.: United States Government Printing Office), 1971, p. 18.

2/ W. L. Picton, Water Use in the United States, 1900-1980, United States Department of Commerce, Business and Defense Service Administration, (Washington, D. C.: United States Government Printing Office), 1960, p. 2.

A 1957 Louisiana research study reported that water use would double in the next 10 or 15 years.[8] Unfortunately, it is impossible to determine whether this prediction has been realized because no records of total water use in the state existed at the earlier date. Actually, the use of water, became a theme of serious concern at the state government level in 1965 when a Legislative Commission contracted with a private firm to make a comprehensive study of water use in Louisiana.

[8] Louisiana Legislative Council, Water Problems in the South-Western States, Research Study, No. 22, (Baton Rouge, 1957, p. 53.

Without contradiction, however, one can say that water use in Louisiana has increased considerably since 1957.

Adding more emphasis to concern over water use, Dr. Herbert Hamilton, President of the Intracoastal Seaway Association and Professor at Southwestern Louisiana Institute in 1959, had this to say:

> ... there are at present, deficiencies and problems of water supply. With increases in population, industrialization, and irrigation, the situation will become more critical. There is enough water in the State of Louisiana to meet all requirements for generations to come, but this water is unevenly distributed. While billions of gallons of water flow unused to the Gulf of Mexico through the Mississippi and Atchafalaya Rivers, areas only a few miles away are confronted with shortages.[9]

A more alarming view was expressed by Lorris M. Wimberly, Director of Louisiana's Department of Public Works at that time. He claimed that, "Water problems (in Louisiana) are far greater and more complicated than those found throughout the United States. The reason for this, is the fact that in addition to ordinary problems of drainage, water supply, irrigation, and navigation, we have problems of flood control, navigation, and salt water intrusions from the Gulf."[10]

Population growth and increase in per capita water use are the basic determinants of an increasing demand for water. The population

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[9] United States Senate, Select Committee on National Water Resources, Water Resource Activities in the United States, 86th Congress, First Session, (Washington, D. C.: United States Government Printing Office), 1966, p. 24333.

[10] Ibid., p. 2489.

of Louisiana in 1970 was 3,641,000 and is expected to reach 5,554,590 by the year 2000. Moreover two-thirds of the population will be located around the five principal cities of Louisiana.[11] During the last decade (1960-70), the urban population increased by 16.8 percent, whereas in the rural areas, only an increase of 3.2 percent was realized. These changes in numbers and distribution of population will not only increase total water use, but add to the problems of distribution which will necessitate heavy investment outlays for adequate distribution of water resources.

With added establishments and expansion of water using industries the demand for water in Louisiana will continue to rise rapidly. Gross volume of water use in 1968, including circulation for cooling by manufacturing industries, amounted to 1,039.9 billion gallons, with a total discharge of 999.2 billion gallons.[12] Further attesting to the growth of industry in Louisiana in this same year, the value added by manufacturing was $1,686.6 million, whereas in 1969, this amount practically doubled to $3,250.3 million. Chemical and allied products accounted for $879.8 million, or about 27 percent of this total.

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[11]Gulf South Research Institute, Comprehensive Water and Related Land Resources Study, Economic Appendix, 1970-2020, (Baton Rouge: Louisiana Department of Public Works), 1972, p. 8.

[12]United States Bureau of the Census, Census of Manufactures, Water Use in Manufacturing, (Washington, D. C.: United States Government Printing Office), 1971, p. 7-95.

The pumpage of water in Louisiana - both ground and surface - increased from 6,704 million gallons a day in 1965,[13] to 9,960 million gallons a day in 1970.[14] This represents an increase of approximately 49 percent. The most striking increase in water use in this five-year period was industrial use which increased from 2,624 million gallons a day to 4,150 million gallons a day (mgd), or a 58 percent increase. Industrial water use constitutes half of the total water requirements of the state, followed by 29 percent for thermoelectric use, 17 percent for agriculture, and 4 percent for municipal use.[15] The most alarming increase in industrial water requirements can be noted in the volume of pumpage in St. Charles parish, which increased approximately 300 percent, from 215.90 mgd[16] to 851.53 mgd,[17] between 1965 and 1970. The greater part of water supplies in the parish was obtained from surface sources, which supplied 837.46 mgd in 1970.[18]

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[13] P. P. Beiber and M. J. Forbes, Jr., _Pumpage of Water in Louisiana, 1965_, (Baton Rouge: Department of Conservation, Louisiana Geological Survey and Louisiana Department of Public Works), 1966, p. 6-7, Table 1.

[14] Don C. Dial, _Pumpage of Water in Louisiana, 1970_, (Baton Rouge: Louisiana Geological Survey and Louisiana Department of Public Works), 1970, p. 8-9, Table 1.

[15] Gulf South Research Institute, _Present and Projected Water Requirements for Louisiana_, (Baton Rouge: Louisiana Department of Public Works), 1971, p. 7.

[16] P. P. Beiber and M. J. Forbes, p. 6.

[17] Don C. Dial, pp. 8-9.

[18] _Ibid_.

On a regional basis, about 90 percent of the industrial water intake of the state is utilized in the three Southern Water Resources Planning Areas (WRPA)[19], (Chart 1), with the South Central WRPA utilizing about 37 percent, the Southeast 34 percent, and the Southwest 20 percent. Analysis of usage in these regions reveals that the three major water using industries -- Chemical and Allied Products, Petroleum Refining and Related Industries, and Primary Metal Industries -- are heavily concentrated in this area and account for the greater share of the recorded water intake. The remaining 10 percent of industrial water intake for the state is concentrated in the three northern WRPA - Northwest, North Central, and Northeast -- where industrial activity is on a relatively smaller scale than in the south.

Agricultural water use in Louisiana includes water used for irrigation, fish farming, livestock and poultry. In 1967, irrigation accounted for 96 percent of the state's total agricultural water requirements of 1,847,618 acre-feet, with practically all irrigation water (99 percent) devoted to rice cultivation. Of the state's total agricultural water intake, 95.5 percent was used for rice production, while other crops utilized 0.7 percent, commercial catfish 1.2 percent, commercial crawfish 2.2 percent, livestock 1.46 percent, and poultry 0.04 percent.[20] Most of the rice production in the state is

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[19] Delineated by the United States Resources Council, for Louisiana, as follows: Northwest, North Central, Northeast, Southwest, South Central, and Southeast.

[20] Gulf South Research Institute, Present Agriculture Water Use in Louisiana, (Baton Rouge: Louisiana Department of Public Works), 1970, p. 6, Figure 2.

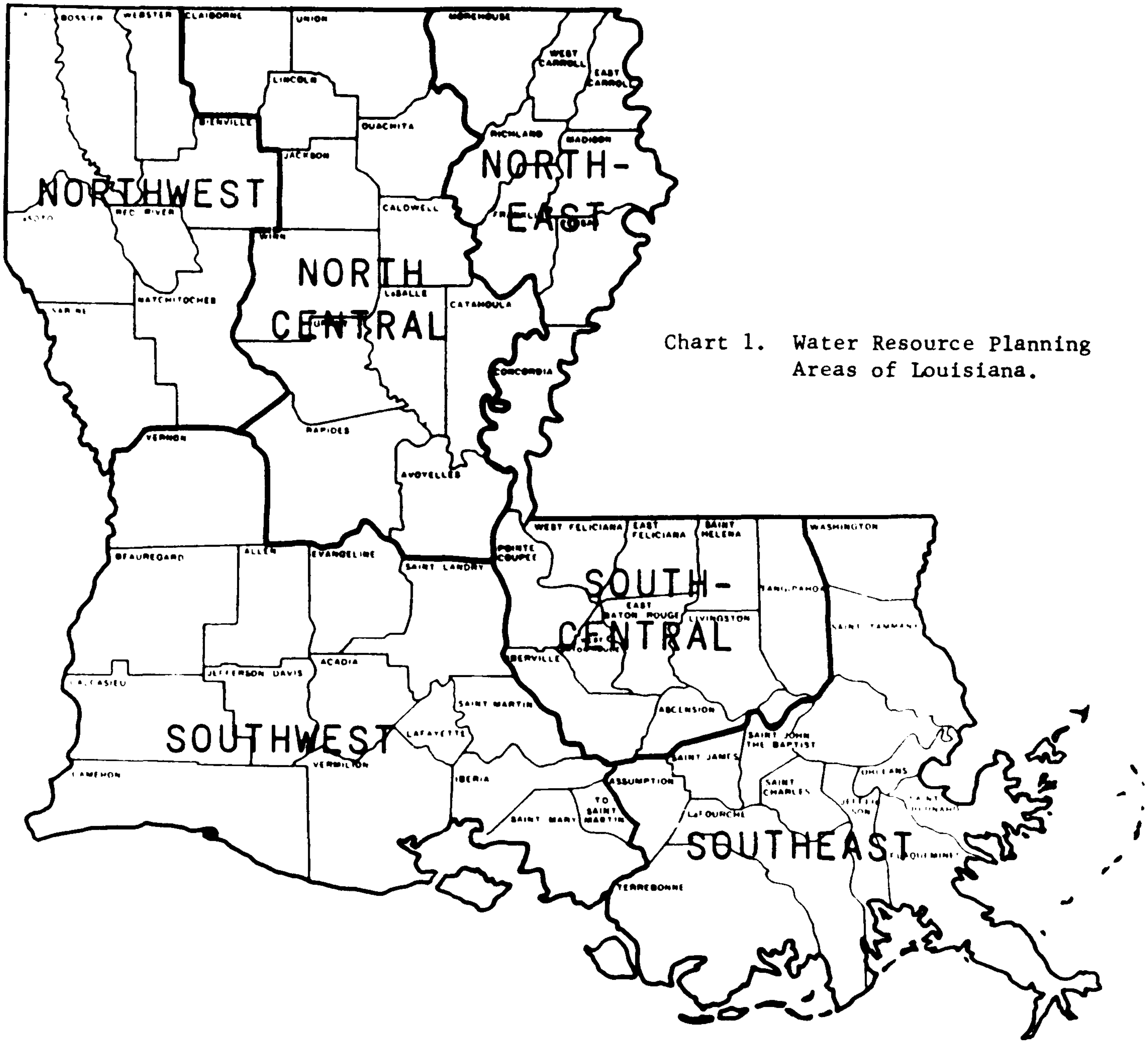

Chart 1. Water Resource Planning Areas of Louisiana.

concentrated in the Southwest region where the largest source of water is obtained from the Vermilion River which supplied 173,968 acre-feet of water in 1967. In this Southwest region 93.3 percent of all irrigation water used in 1967 was utilized in the production of rice. Since the rice season generally extends from April to September, this period becomes of critical importance in the planning of future agriculture use of a limited water resource.

Municipal water usage in Louisiana in 1967, totaled about 139 billion gallons serving a municipal population of 2.9 million and thereby reflecting a consumption of 132 gallons per capita per day.[21] Eighty-five billion gallons, or 54 percent of the water, were obtained from surface sources (79 percent from the Mississippi), and 46 percent from ground sources. Again, the Southeast WRPA used more than half of total municipal water supply because of population concentration in Jefferson and Orleans parishes, consumption in that region was estimated at 165 gallons per day per capita. As expected in each region, population size correlates directly with the amount of municipal water used per capita.

In terms of projected water requirements, the Gulf South Research Institute predicted that total water requirements of Louisiana will reach 16,279.7 million gallons per day (mgpd) in 1980 and 35,817.1 mgpd

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[21]Gulf South Research Institute, Present Municipal Water Use in Louisiana, (Baton Rouge: Louisiana Department of Public Works), 1969, p. 6, Table 1.

in the year 2000.[22] On the basis of the 1970 level, this will represent an increase of approximately 60 percent in 1980 and 260 percent by 2000 (see Table 2).

Table 2. Total Water Requirements (Million Gallons Per Day) for Louisiana by Use Category, Yearly Average, 1970-2000

Use category	1970	1980	2000
	- - - - -	Million gallons per day	- - - - -
Municipal	416.0	549.0	801.9
Agricultural	1,637.5	2,896.8	3,245.9
Industrial	4,969.4	7,968.3	19,643.2
Thermoelectric	2,890.2	4,865.6	12,126.1
Total	9,913.1	16,279.7	35,817.1

Source: Gulf South Research Institute, Present and Projected Water Requirements for Louisiana, 1970-2020, Baton Rouge: Louisiana Department of Public Works, 1971, p. 6.

The largest increase in water demand in Louisiana is expected in terms of industrial requirements. It is estimated that when compared to 1970 levels, water demand by industries will about double by 1980 and increase about four times by 2000. Similarly, agricultural and

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[22] Projected data, unless otherwise stated, were obtained from: Gulf South Research Institute, Present and Projected Water Requirements for Louisiana, 1970-2020, (Baton Rouge: Louisiana Department of Public Works), 1971.

municipal requirements will double by the end of the century, with thermoelectric requirements increasing more than fourfold. The peak requirements normally will be expected between the months of April to August.

On a regional basis, the Southeast, Southwest, and Northeast regions are expected to double their water requirements by 1980 (see Table 3). By the year 2000, all regions will require approximately four times as much water in comparison to the 1970 levels of water use.

Table 3. Yearly Average Water Requirements by Water Resource Planning Areas (WRPA) in Louisiana, 1970-2000

WRPA	1970	1980	2000
	- - - - -	Million gallons per day	- - - - -
Northwest	379.6	678.2	1,713.4
North Central	415.9	683.5	1,650.9
Northeast	153.9	308.7	475.7
Southwest	2,969.5	4,959.0	8,770.0
South Central	2,122.1	3,609.1	9,415.5
Southeast	3,854.1	6,041.2	13,791.6
Total	9,913.1	16,279.7	35,817.1

Source: Gulf South Research Institute, *Present and Projected Water Requirements for Louisiana, 1970-2020*, Baton Rouge: Louisiana Department of Public Works, 1971, p. 9.

Since this study deals with the pricing of water, it is necessary to examine briefly the sources of water (ground and surface) in the context of user requirements. Under existing conditions, no physical shortage of surface water is expected within the next three decades, but "with the proposed export of water to Texas and New Mexico from the lower Mississippi Valley," a shortage may well be expected in future years if the proposal materializes.[23] This diversion of water will result in a forecasted deficit of approximately 2,700 mgd of ground water for the year 2000.[24]

This deficit will not be felt equally across the state. On a regional basis, the deficit may be apportioned as 46.7 percent in the Southwest; 39.2 percent in the South Central; 7.7 percent in the North Central; 4.5 percent in the Southeast; 2.0 percent in the Northwest and 0.4 percent in the Northeast. Moreover, by the year 2000, total ground water requirements for Louisiana will increase by 150 percent (4,036 mgpd), municipal requirements 100 percent (328 mgpd), agriculture 77 percent (1,487 mgpd), and industrial 300 percent (2,062 mgpd).[25]

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[23] Harry P. Burleigh, John T. Pegg, Calvin T. Watts, and Jack W. Fickessen, "Export of Mississippi River Water to Texas and New Mexico -- Joint Discussion," Journal of American Water Works Association, Volume 62, No. 6, June 1970, p. 371.

[24] Gulf South Research Institute, Ground Water Resource Requirements for Louisiana, (Baton Rouge: Louisiana Department of Public Works), 1971, p.11.

[25] Gulf South Research Institute, Present and Projected Water Requirements for Louisiana, 1970-2020, op. cit., p. 6.

The Problem

From the prognostications, it appears that the critical water resource problem in Louisiana will be one of proper allocation, and this allocation will depend to a large degree on water pricing policies in the state. This applies equally to waters derived from both ground and surface sources, although no shortage of the latter is expected in the near future.

Increases in the demand for water will result in competition, not only among domestic consumers but also among use categories as well. Even with total physical supply exceeding demand by the end of the century, increasing costs will be incurred in distributing and providing the water at the right time in adequate quantities and in acceptable quality. These costs must be reflected in the price charged for water in order to allow its economic allocation among its competitive uses. The price mechanism serves to provide checks and balances in the production and consumption of economic goods and services. Water is an economic good and its optimum allocation should be based on economic criteria through the use of the price system.

Controversy over water pricing is rather widespread. Recently a water pricing problem was encountered locally when a government franchised water works company petitioned and gained approval from the Louisiana Public Service Commission to impose a 40 percent increase in water rates on residents outside city limits.[26] The City Council

[26]Morning Advocate, (Baton Rouge), June 13, 1972, pp. 1 and 10-A.

objected to the hike, with one councilman claiming current rates were "entirely too high" and another requesting that rates of "all utilities" be studied.

In Louisiana, according to a water resource report, the highest price for municipal water was found in Assumption parish where the average charge was $10.60 per 10,000 gallons per month.[27] On the same volume basis, it was $2.31 in Point Coupee parish and $2.50 in Orleans parish. However, on a regional basis, the highest average price of $6.41 was found in the Northeast while the lowest price of $3.69 was found to prevail in the Southeast, the region with the highest per capita water use in the State of Louisiana. These price differences vary considerably among the regions. As demand continues to increase, the pricing structure of water becomes more critical in attempting to allocate the water resource among competing uses and users.

Objectives and Scope of Study

The pricing of water is a broad and complicated subject. In the progress of this study the various aspects of supply, demand, and costs will be explored for three categories of water use, namely, residential, industrial, and agricultural. A review of past literature has failed to reveal any research that analyzed water prices and uses among all of these categories at the same time. A few dealing with water pricing, and relatively few indeed, were devoted either to the pricing of residential and/or industrial or agricultural water

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[27] Gulf South Research Institute, Present Municipal Water Use in Louisiana, op. cit., p. 49, Table XIII.

separately. For Louisiana, this study promises to be the first comprehensive and systematic study of this nature ever undertaken. It is deemed a particularly important topic for research in that water resources have been and still are a major factor in the growth and economic development of Louisiana.

Water as economic good has been traditionally viewed as a "cheap" or subsidized commodity. Very rarely, if ever, has any emphasis been placed on use and allocation based on relevant economic criteria. Economic theory, in the past and even currently, has found limited use in the pricing mechanism to assure economic allocation of the resource among its competitive use and user categories. Pricing policies are generally entrusted to engineers and politicians with very little training in the economics of water supply and demand. Current pricing policies are based primarily on revenue requirements of the supplying units. Costs involved in providing adequate supplies of an acceptable quality have generally played a secondary role in the determination of price. This study evaluates these costs as primary factors in price determination and consider their use in arriving at a more efficient allocation of the resource.

To accomplish this, emphasis will be placed on the theory of marginal cost pricing in contrast to average cost pricing which is most commonly observed among makers of water rates. Marginal cost pricing requires that prices must be equal to the costs of supplying a product (water) at the margin or the cost of the last unit supplied. Production of an extra unit of water that is priced at a level below the extra cost leads to an inefficient use of water resources. It means that the value (price) of the extra unit of water to the consumer is less than the value of resources that go into its production. Too much of the product is being produced and consumed which in turn means that too much of society's scarce resources are tied up in its production and, accordingly, too little is available for the production of other goods and services.

This study examines the economic aspects of water supply pricing in Louisiana. To accomplish this, a major purpose is to review and evaluate the current practices followed in establishing rates for residential, industrial, and agricultural water use, i.e., the total water use complex in Louisiana. Discussion will be confined to those specific areas and, in order to facilitate analysis and evaluation, the objectives are stated as follows:

(1) To examine pricing theory and policies for essential commodities that are characterized as being sometimes limited and sometimes in excess supply, or as a flow resource which has been traditionally regarded as a free good.

(2) To review price structure and pricing policies of public and private water companies in humid, semi-humid, and arid regions of the United States.

(3) To examine and evaluate the price structure and pricing policies for major water uses in Louisiana; and

(4) To explore policies based on relevant economic criteria in water pricing with the aim of assuring adequate water service to agricultural, industrial and residential consumers in the State of Louisiana.

Method of Investigation

Data on the economic aspects of water pricing in Louisiana are limited since, traditionally, water supplies have been plentiful and most research work on the resource up to the present time was devoted to the solution of technical and physical water problems. Data for this study were acquired from primary sources concerning water supply costs and water pricing policies in Louisiana.

With respect to water supply systems, a questionnaire was designed to acquire relevant information pertaining to the organization of water utilities, their production and distribution systems, price schedules, bases of price determination, and the financial status of the utility (see the questionnaire in Appendix A).

Since no complete directory of water utilities in Louisiana was available, a mailing list was compiled from the following sources:

(1) Municipal Water Works Superintendents, State of Louisiana, prepared by the Engineering Division, Louisiana State Department of Health, New Orleans, Louisiana, September 1969.

(2) Louisiana Public Service Commission where the annual reports of all private water utilities in the state are received; and

(3) Farmers Home Administration, United States Department of Agriculture in Alexandria, which generally finances the establishment of nonprofit water systems in rural areas of Louisiana.

Addresses collected from these sources were checked to avoid duplication and a mailing list of 317 water utilities was derived. Accordingly, 317 questionnaires were mailed on October 15, 1972, with a six-week period allowed for returns. By November 30, 1972, 168 completed returns were received. Due to this limited response a second questionnaire was sent as a reminder on December 5, 1972, and this resulted in an additional 101 responses, thereby resulting in a total of 269 replies, of which 231 completed questionnaires were usable. The data obtained were coded for tabulation and analysis based on two factors: population served and ownership of water utilities.

From the water utilities surveyed, there were 86 non-respondents to the questionnaire. These non-respondents were municipally-owned water utilities primarily serving small urban populations. The 54 municipal water utilities which responded included those which served all major urban areas. They were adequately distributed at different population levels across the state. (See Appendix B for this distribution).

Since about 93 percent of all agricultural water is used in the rice producing area of Southwestern Louisiana, information on agricultural water use relates principally to water supply and demand characteristics and their influence on costs and prices in the production of rice in Louisiana.

Attempts to acquire cost-pricing information for industrial water use met with limited success. Nevertheless, some basic data were supplied by a large industrial plant and the analysis of its cost-pricing data, although not representative industry-wide is indicative of water use by the chemical and allied industries, the major users of industrial water in Louisiana. To supplement the limited responses from industrial groups, secondary data were obtained from numerous industrial references as to physical and economic characteristics of industries and their use of water.

Statistical techniques used in the analysis of water systems are based primarily on arithmetic averages in conjunction with tabular and graphical presentation of frequency distributions. Regression and correlation analysis was used to measure functional relationships between population served and total operating costs incurred from the provision of water for residential use.

Organization of Dissertation

In Chapter I, the role of water resources in society is examined with special reference to Louisiana. The current water use situation in the state and projected water requirements are reviewed. This chapter also includes the scope and objectives, method of investigation, and organization of the thesis.

The role of price theory in the allocation of water resources is provided in Chapter II. Emphasis is placed on pricing in an imperfect market in order to evaluate the current market structure and its ramifications under which the pricing structure of the industry current operates.

A review of water pricing policies in arid, humid, and semi-humid areas of the United States is presented in Chapter III, in order to identify differences, if any, of such policies due to geographical and climatic variations among areas.

Chapter IV examines the economic characteristics of water supply and demand for residential use as a necessary step leading to the evaluation of water costs and water rates. This latter evaluation is accomplished in Chapter V where other special charges and the financial status of water utilities are analyzed.

In Chapters VI and VII, the pricing and costs of water use in agriculture and industry respectively are analyzed. An extensive review of factors affecting the cost-price relationships in both these uses is also presented therein.

The application of the economic concepts of cost and pricing in water resources in Louisiana is analyzed in Chapter VIII together with a proposed water pricing policy based on the theory of marginal cost.

Finally, a summary and conclusion is presented in Chapter IX.

CHAPTER II

THE ROLE OF PRICING THEORY AND POLICY IN WATER RESOURCES

The Role of the Price System

The price system is the mechanism which allocates resources in a market economy. Imperfections in this system can result in misallocation of resources which, characteristically, are limited in quantity, yet can be combined in varying proportions to produce a given commodity. This price system fosters consumers' sovereignty, since consumers, through the price mechanism, transmit their wants to producers who respond by organizing production with the aim of increasing output, attaining economic efficiency and consequently, maximizing profits. The profit motive is recognized as the critical element in a free market economy which influences production or response to the price system.

Generally, prices function as a governor in asserting checks and balances on production and consumption. They play this role not only in the marketing of private goods, but also in regulating the consumption and production of certain goods and services produced by government, i. e., public goods and services.[1] An additional function of

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[1]Robert K. Davis and Stephen H. Hanke, Pricing and Efficiency in Water Resources Management, (Springfield, Virginia: National Technical Information Service), Report NWC-SBS-72044, p. 2.

price, which is still debated among economists, is that the price system should provide for maintenance and economic growth of the economy. Leftwich states:

> The role of the price mechanism and its degree of importance in providing for economic maintenance and growth are not clear...(since) prices and profit prospects are an important element in determining whether or not maintenance and growth occur.[2]

Besides these traditional functions, Boulding adds yet another one in which he asserts the long-run function of the price system is to direct the process of technical change.[3] He states:

> Inexpensive products (such as water) are not economized, and attention is not drawn towards their economization. On the other hand, the course of technical change always tends to work toward eliminating the costly and dear. This is a principle of great importance in the development of water resources.[4]

The importance of this principle relates to the fact that water as a cheap commodity, in relatively abundant supplies in the past, has not fostered the development of technology towards its efficient use and conservation. However, with scarce supplies, as now evident in many areas around the world, the resource will become costly, and technological developments in the form of water saving elements will more likely

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[2]Richard H. Leftwich, The Price System and Resource Allocation, Third Edition, (New York: Holt, Rinehart, and Winston), 1966, p. 20.

[3]Kenneth Boulding, "The Economist and the Engineer: Economic Dynamics of Water Resource Development," Stephen C. Smith and Emery N. Castle (Eds.), Economics and Public Policy in Water Resource Development, (Ames: Iowa State University Press), 1964, pp. 90-91.

[4]Ibid.

come forth to reduce higher costs associated with water use. An indication of this trend, currently, is the application of scientific knowledge in the process of desalinization which, hopefully, will make additional supplies of water available at reasonably low prices.

Much of the foregoing assumes pricing in a perfectly competitive market which, in comparison to other market structures, attempts to provide for optimum resource allocation. Characteristics of a perfectly competitive market include, homogeneity of product, large number of sellers and buyers, free mobility of resources, and absence of artificial restraints on demand, supply and product price. These characteristics do not exist in the water market and as a result common water pricing practices are based on an imperfect market where imperfections relate to regulated prices, water rights laws, public ownership of water resources and monopoly power of supplying firms.

It may be useful to indicate at this point that water is both a stock and flow resource;[5] and also, both an input or output depending upon the production unit. However, being renewable, it is generally considered as a flow resource, i. e., where different quantities become available at different intervals of time. It differs from other flow resources such as sunlight and wind in that it is storeable and transportable, and because of this, there should be no shortages in a physical sense, but only in economic terms. As a result, it is used

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[5] S. V. Ciriacy-Wantrup, Resource Conservation: Economics and Policies, Revised Edition, (Berkeley: University of California, Agricultural Experiment Station), 1963, pp. 37-38.

normally as an input in agriculture and industry while from a water utility standpoint, it is an output for consumptive use--specifically for personal, residential, and commercial uses.

The Role of Price Theory in Current Water Pricing

The Nature of the Water Market

As mentioned previously, one of the functions of the price system is the efficient allocation of resources. This function is basic to any understanding of the pricing of water under perfectly competitive conditions. The market price is determined by the forces of supply and demand for water. Shifts in the supply and/or demand for the resource, can result in either the same of different equilibrium prices depending upon the magnitude of the shift and the elasticity of the supply and demand curves.

In the water market, there are certain built-in imperfections which hinder the functioning of a purely competitive market in determining the price of water. These imperfections have generally resulted in a market structure which conforms closely to pure monopoly where a single seller exercises control over price or output determination.

One of these imperfections is the existence of technological interdependencies, where one person's consumption or production automatically affects another's production or consumption because they are physically linked.[6] This stems primarily from the flow characteristics

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[6] F. M. Bator, "The Anatomy of Market Failure," Quarterly Journal of Economics, Volume LXXII, August 1958, pp. 351-379.

of water which caused some economists to characterize it as a "fugitive" resource.[7] When flow is unhindered, the availability of water will vary, and as a result its impoundment may become necessary. Even with impoundment, however, the specific use of water through pumping say in agriculture, from both ground and surface sources affects the production and consumption in other uses. The quantity available at a given time is diminished with respect to the demands by other users.

The fugitive nature, specifically with reference to surface water, has resulted in the formulation of water rights doctrines, which constitute another imperfection in the water market. These doctrines are: (1) the Riparian or Correlative Rights, and (2) the Appropriation or Seniority Rights. Each of these rights involves elements of monopoly power and as a consequence affects competitive pricing. Moreover, these rights are difficult to define precisely and therefore do not facilitate their trading freely in a competitive market structure.

A further imperfection in the water market is the generation of technological indivisibilities, or the creation of externalities which in turn create a divergence between private and social costs.[8] These indivisibilities foster "spillover" effects of private citizens upon other members of the community and as a consequence the costs associated

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[7] Jack Hirshleifer, James C. DeHaven, and Jerome W. Milliman, Water Supply: Economics, Technology, and Policy, (Chicago: University of Chicago Press), 1963, p. 79.

[8] C. E. Ferguson, Microeconomic Theory, Revised Edition, (Homewood: Richard D. Irwin, Inc.), 1969, p. 463.

with the spillover are borne by others rather than the actual producer. A good example of this is the excessive pumping of underground waters by one pumper who, because of his actions, forces others to incur greater costs for which no direct benefits are received. Unless these costs can be defined and pinned to the pumper, then competitive pricing is impracticable. This "common pool" resource characteristic is very common in the case of irrigation water.

Another reason for the failure of competitive pricing rests with the case where decreasing average costs of production are incurred. Under such circumstances, it would be impossible to utilize purely marginal cost pricing, since marginal costs at any level of output would be less than average costs.[9] This characteristic is a source of justification for public intervention and public investment in water resources, since such investments are generally regarded as heavy and "notchy". Unless, a water plant characterized by decreasing average costs is able to achieve an optimum rate of output, i. e., the point where average cost is minimum, it will fail to capture the total costs of production, if competitive market price is below average total cost.

Apart from being an economic good the common conception associated with water use is that each individual has an "inherent" right to a minimum amount of water to insure his physical survival. It is this conception which further justifies public ownership to water establishments aimed at providing water at reasonable prices. At times these

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[9] F. M. Bator, _op_. _cit_., p. 351.

water prices have in reality failed to cover the average cost of production. Under such circumstances the profit motive is not the major incentive for production. As Bain et al, states, "The water market is populated mainly by public enterprises which are not profit seekers; it operates substantially without markets for water; its performance thus emerges from the quasi-insular policies and actions of many water agencies serving captive audiences."[10] These audiences further complicate the market and the free pricing system by the introduction of pressures through the political process. In recognition of this, Kelso enumerated four false images generally associated with water use: the survival image, the irrigation fundamentalism image, the desert image, and the free good image,[11] all of which are impediments to the functioning of the competitive price mechanism. This institutional aura surrounding water, he claims, results in policies and institutions which do not facilitate improved performance in the water industry. In fact these images, not water shortages, are largely responsible for current water problems. Moreover, the industry is ailing because the policies and institutions which govern it do not perform at the optimum or overall economically efficient level in a manner which comes even tolerably close to best serving the public interest.[12]

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[10] Joe S. Bain, Richard E. Caves, and Julius Margolis, Northern California's Water Industry, (Baltimore: The Johns Hopkins Press), 1966, p. v.

[11] Maurice Kelso, "Competition for Water in an Expanding Economy: Policies and Institutions," Conference Proceedings on Water Resources and Economic Development of the West, Western Agricultural Economics Research Council, Report No. 16, 1967, p. 194.

[12] Ibid.

An imperfect market in the pricing of water resources, has led to the development of different pricing theories, each characterized by some element of monopoly power. In providing residential water services the water utilities are usually monopolies with prices based on the theory of average cost pricing and regulated by government in order to provide for a "fair" return on investment. In industry and agriculture, a similar situation may exist, but the general policy is to charge a price below the average cost of production, especially in communities where great emphasis is placed on economic and social development. In providing water service, water utilities always exercise some degree of monopolistic control even without regulation by a state agency or commission. Government intervention thus becomes necessary in the pricing of water in order to regulate their earnings at an acceptable level. Because of these regulatory practices this section deals with price theory and its use in regulated pricing of residential water. Later sections are dedicated to the pricing of agricultural and industrial water.

Pricing Theory for Residential Water Use

An important characteristic of water utility pricing common today, is the lack of economic pricing. The rate schedules of water utilities are designed by engineers and politicians with limited or practically no training in the economics of resource allocation. The fundamental premise of these "rate-makers is to set rates at levels which will generate annual revenue requirements to cover the average cost of production. This approach often results in waste of water resources and over-investment in supply facilities.

Another area of deficiency in water pricing theory arises from the fact that water use is based on the management of supply and not demand. Generally, the supply of water is constrained by its costs of production, but the regulated price charged by water utilities for such water is so low that relatively no restraint is placed on consumer demand. Davis and Hanke state that "demand management through (responsive) pricing is at variance with standard pricing practices; (the current) prices are almost never used to control uses."[13] This situation is of serious concern for water utilities where flat rates are common for, based on this practice, the marginal cost of water to the consumer can be considered as zero. Unless, the price charged for water reflects both supply and demand conditions in the market, current pricing practices will continue to be deficient in the production and consumption of the resource.

Since, monopoly power is a common characteristic in water marketing, regulation of such power by government is essential to assure an equitable allocation of water resources. Regulation by government is normally entrusted to an independent commission which regulates the level of rates consistent with the revenue requirements of the utility, and at the same time attempts to assure a "fair" return on investment. The rate schedules, however, are developed by the water utility's management staff and, generally, such schedules exhibit the principle of differential

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[13] Robert K. Davis and Stephen H. Hanke, _op. cit._, p. 4.

pricing among water uses and users. An example of this principle is the declining block rate schedule which not only provides voluntary discounts for larger volumes of consumption but also imposes a relatively higher price for residential water than that sold for industrial use. This method of water pricing, which is the accepted public policy today, is alleged to be discriminatory when the different rates charged to different consumers do not reflect their corresponding costs.

Because of joint costs incurred in the production of water served to different classes of customers, regulatory commissions are faced with the difficult task of allocating such costs. Because of this difficulty, the common practice of these commissions in regulation of rate levels is based on average costs, irrespective of the customer class served by the water utility. Obviously, average price differentials do not reflect the differential costs incurred in providing water services to the different customer classes and, in the context, water utility pricing practices are considered discriminatory.

Figure 1 illustrates, the determination of price by a pure and unregulated monopoly which, by definition, has complete control over its supply or price, with entry to the market barred to other water utilities or firms. The price charged for the quantity of water Q_1 is P_1 and is higher than that of a purely competitive price. Profits in excess of a normal return are represented by the area P_1ABP_2. The realization of excess profits is not consistent with public utility pricing policies, and because of this, rate levels are regulated by government to achieve a fair return level such as P_3. At any price above P_3, the water utility will earn a monopoly return, but this is not so at any price below it, since average revenue (AR) would then be less than average cost (AC). It should be pointed out that utilities cannot

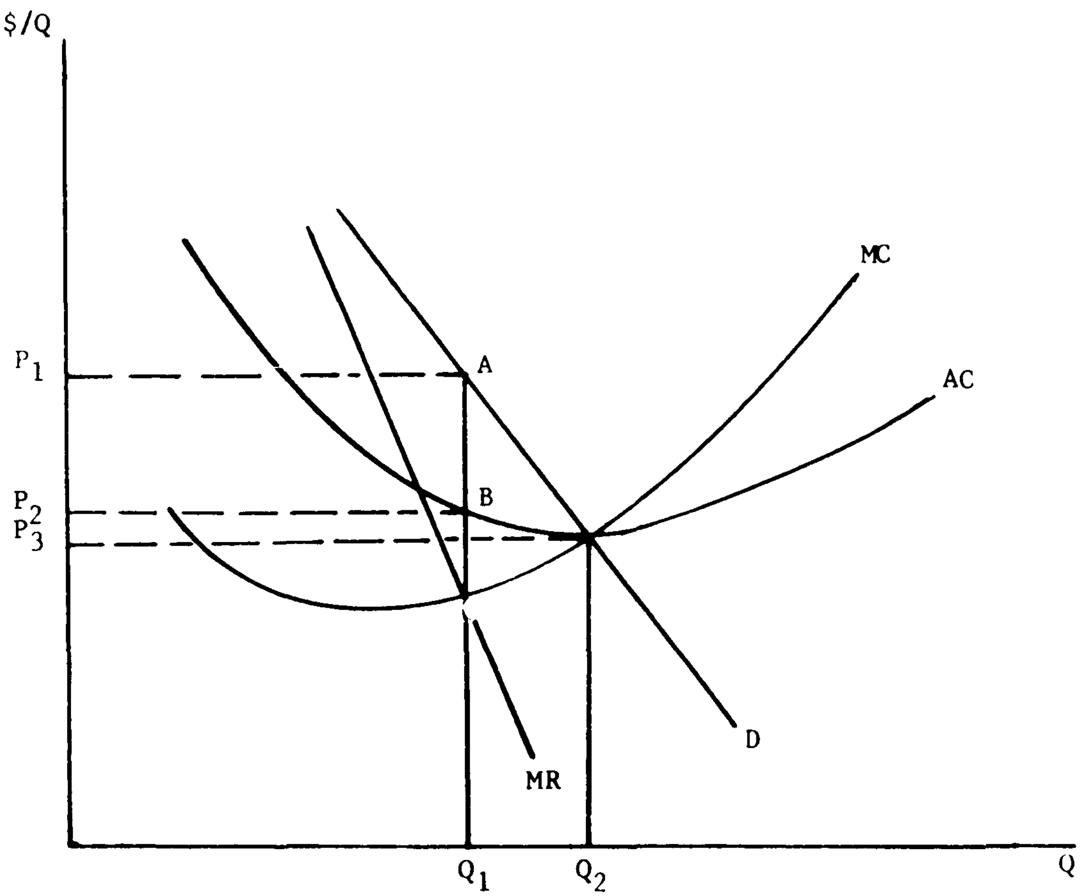

Figure 1: Price and Output Determination in a Regulated Monopoly

exceed their regulated prices, but in all circumstances, they are free to offer price reductions to any class of customers.

To understand the regulation of monopoly pricing further, Figure 2 indicates the classical case of differential pricing through price reductions, despite regulation by government. Here the price P_1 would not be approved by the regulatory agency since it is greater than the average cost of production. The price consistent with regulation would be established at P_2 instead where it is equal to the average cost of production. At this price the total revenue generated is equal to the total cost of production.

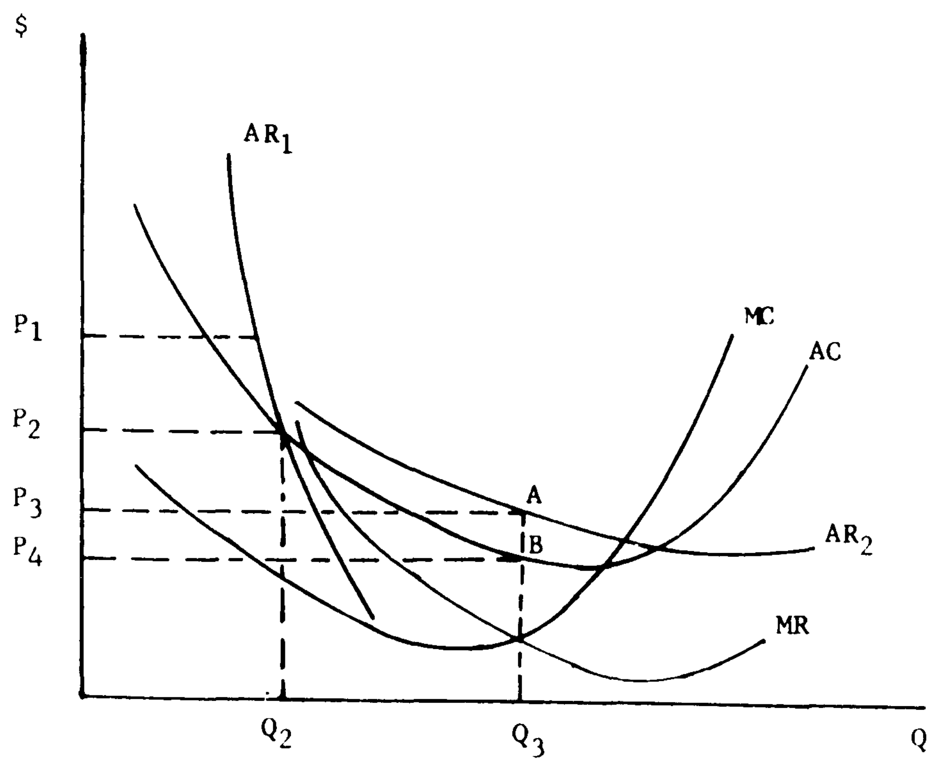

Figure 2: Differential Pricing in a Regulated Monopoly

This regulatory pricing practice of equating total revenue with total cost, however, does not necessarily prevent the operations of a water utility from being profitable. As such the regulatory agency does not change the demands of consumers since there are consumers who are willing to purchase water at lower prices than P_2. Because of differences in demands, say between residential and commercial customers, the water utility can pursue a policy of price differentiation to make its operations profitable despite the regulatory control of its earnings.

This policy of differential pricing with regulation is illustrated in Figure 2.[14] The regulatory agency fixes the price P_2 which is equal to AC and AR_1. Then to achieve price differentiation the water utility separates consumer's demands into two parts as shown by AR_1 for residential customers and AR_2 for commercial customers. Under these circumstances, the water utility accepts the regulated price P_2 at AR_1 for residential customers whose water consumption is generally a small but constant amount, say at Q_2. For commercial customers, characterized as large volume users, the water utility can charge the price P_3 which is determined by the intersection of its MC and MR curves (derived from AR_2). At this price, the water utility makes a monopoly profit equivalent to the area P_3ABP_4. Although theoretically plausible, the realization of monopoly profits is inconsistent with the goals of regulatory commissions.

Apart from government regulation, the slope of the marginal cost is an important element in the economics of water utilities, since it affects the quantity-discount price or prices than can be offered to customers. In Figure 3, assuming profit maximization and a regulated price of P_1, the water utility with a marginal cost curve of MC_1, can offer differentiated prices ranging between P_1 and P_2.[15] However, where marginal cost is constant as with MC_2, the price range would extend between P_1 and P_4. A constant marginal cost over a range of output is not uncommon among public utilities and in such cases a price charged would be equal to both the average and marginal cost of production.

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[14] Emery Troxel, Economics of Public Utilities, (New York: Rinehart and Company), 1947, p. 553.

[15] Ibid., p. 632.

Weiss states that in this case "the commissions' policy and the economists' recommendation (marginal cost policy) would come to about the same thing."[16]

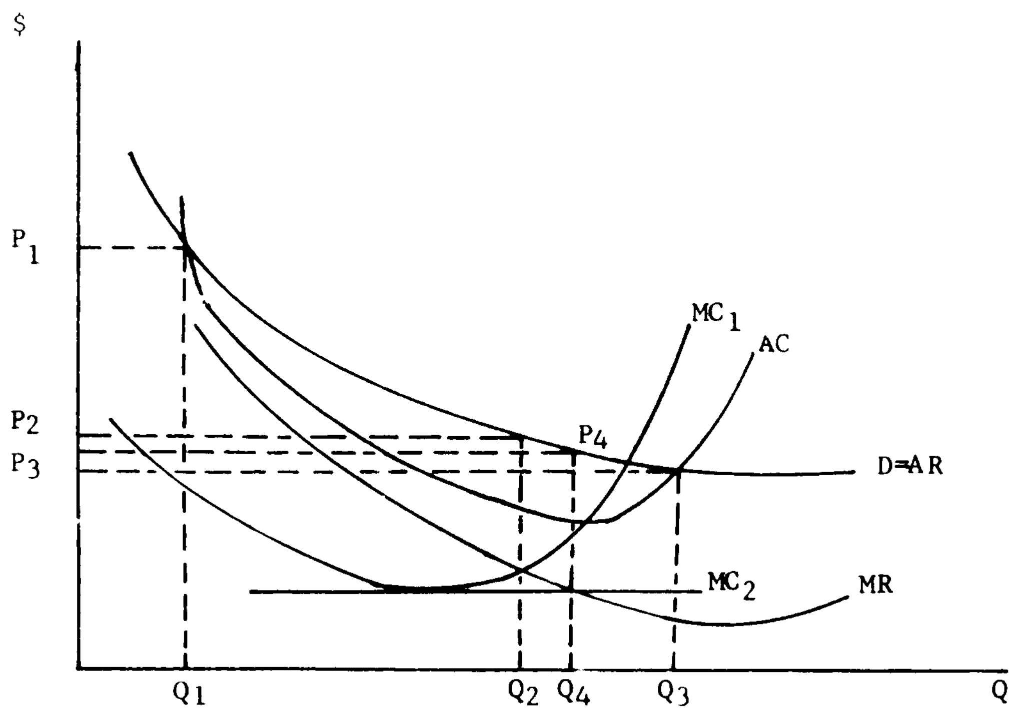

Figure 3: Price Discrimination in Water Utility Pricing

Although the foregoing discussion and diagrams provides a theoretical explanation of monopolistic pricing principles generally associated with water utilities, it should be noted that in actual practice, water utilities make only approximate applications of such principles. A characteristic limitation is that of profit maximization by equating marginal cost and marginal revenue. Troxel warns that the knowledge

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[16] Leonard W. Weiss, Economics and American Industry, New York: John Wiley and Sons, 1967, p. 235.

of water utility managers with respect to cost and demand is imperfect for they "do not use the concepts of marginal cost and marginal revenue in precisely the same way that economists use them".[17]

The degree of discriminatory pricing practiced by water utilities depends upon the number of classes of customers served and the price elasticity of demand of each customer class. Where a single customer

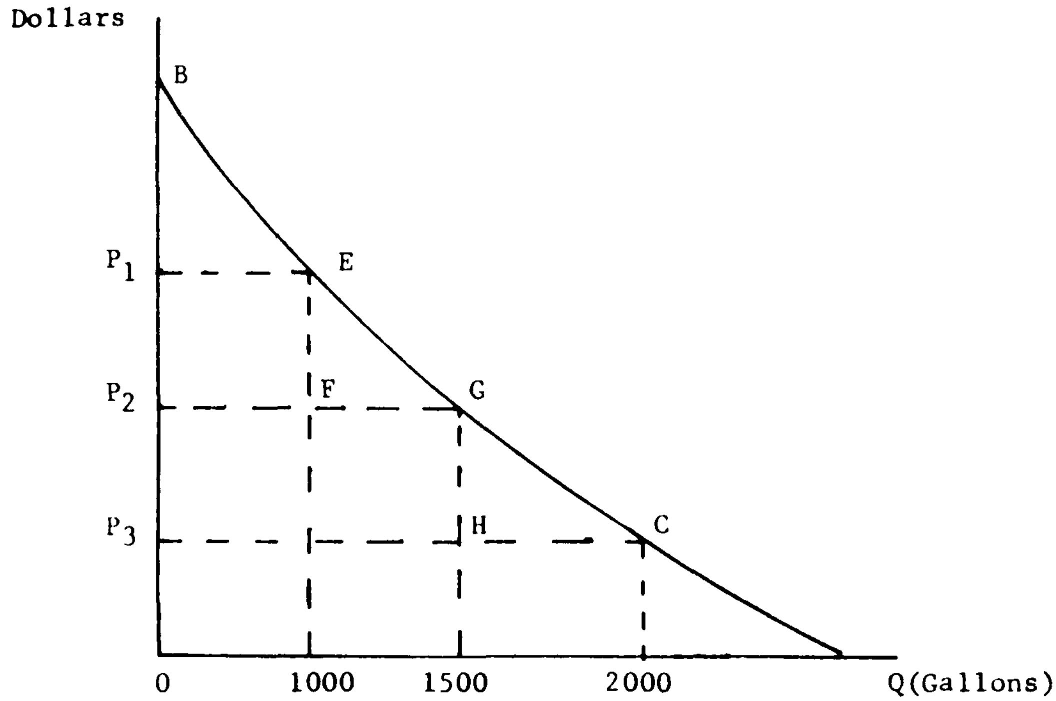

Figure 4: Second Degree Price Discrimination

class is served, water utility pricing policy is characterized as second-degree price discrimination via declining block rates. For example in Figure 4, the water utility charges a given price of P_1 for the first 1,000 gallons of water, a lower price of P_2 for the next

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[17] Emery Troxel, op. cit., p. 554

500 gallons and still a lower price for all additional gallons during the time period. If the consumer were to use 2,000 gallons during a month, he would pay 1,000 $P_1 + 500 P_2 + 500 P_3$. This payment is greater than the amount that would have to be paid without discrimination since 2,000 $P_3 < 1{,}000 P_1 + 500 P_2 + 500 P_3$. Actually, the consumer loses some of his consumer surplus,[18] for without discrimination purchasing 2,000 gallons at a price of P_3, the consumer surplus is given by the area BP_3C. With discrimination this surplus decreases to $BP_1E + EFG + GHC$ which is less than BP_3C.

Although second-degree price discrimination is most widely practiced some water utilities also practice third-degree price discrimination. This is particularly true where more than one customer class is served and different price elasticities of demand exist in each customer class. Normally, the price elasticity of demand for residential water is relatively inelastic and, as a result, higher prices are charged to this customer class. On the other hand, lower prices are accorded to industrial or commercial customers, whose price elasticity of demand is fairly elastic. From the standpoint of the water utility, this pricing practice may be sound economic policy, since a higher price in the inelastic customer class and a lower price in the elastic customer class will generate a larger amount of total revenue necessary to recover the costs of production.

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[18]Consumer surplus is defined as "the amount over and above the price actually paid that a man would be willing to pay for a given commodity rather than go without it." See G. J. Stigler, The Theory of Price, (New York: The Macmillan Company, 1966), p. 78.

The support for the cost-price standard in water utility practice is founded on two arguments which have enabled it to gain popularity and consequent social acceptability.[19] First, it relates to the rationing function of consumers under the principle of consumer's sovereignity, whereby potential consumers would be able to purchase any amount of water service providing they are willing to compensate producers and society for the costs of rendering the service. Consumers in purchasing the service will purchase that quantity whereby they are able to relate its costs with the benefits received. Moreover, any difference in this accepted price can either encourage more use of water, when the price is less than average cost, or limit the necessary quantities to consumers if price is greater than average cost. Second, the need for tax-financed subsidies, common among municipally owned utilities, will be eliminated since the total revenue generated should be sufficient to recuperate the total cost of production.

The pricing policy of water utilities occasionally differentiates prices based upon the demand capacity placed on the system, i. e., peak-load pricing. Under this pricing policy, the problem of joint costs determination becomes inevitable where the water utility is serving the same quality of water to different classes of consumers. Utilities attempt to allocate costs according to the consumption of each buyer group during

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[19] James C. Bonbright, Principles of Public Utility Rates, (New York: Columbia University Press), 1961, pp. 69-70.

the peak period. Because of the difficulty in sorting out cost components of joint costs, the price schedule is usually determined arbitrarily by many utilities.

The on-peak and off-peak pricing is not discriminatory if each customer or group of customers is held accountable, through prices, for

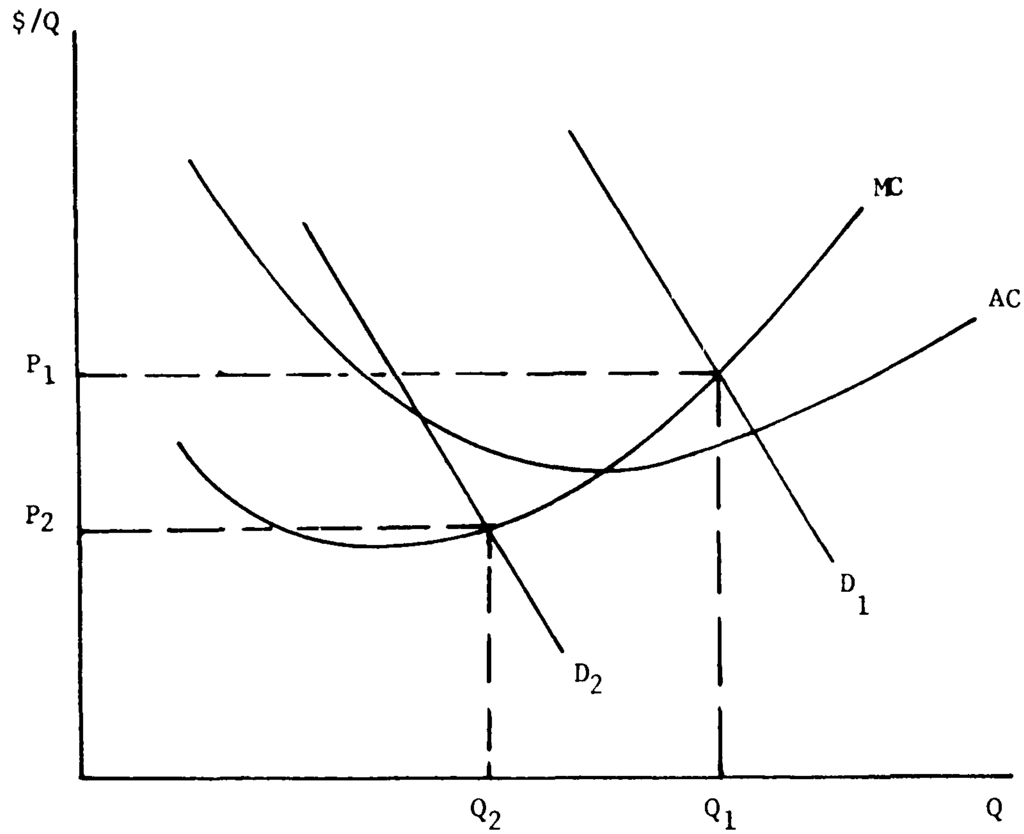

Figure 5: On-Peak and Off-Peak Pricing by Water Utilities

the corresponding costs incurred. As such it is not as serious a problem with water as for electric power and transportation utilities, since water is technologically storeable and transportable.[20]

Despite the difficulty of joint cost allocation with off-peak and

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[20] P. O. Steiner, "Peak Loads and Efficient Pricing," Quarterly Journal of Economics, Volume LXXI, November 1957, p. 585.

on-peak pricing, Figure 5 indicates the situation where the marginal cost (MC) of providing water at peak demand is high and the price is P_1. At off-peak, where the marginal cost is relatively low the price is P_2. However, since the determination of such prices is not practiced by water utilities, the most common policy is based on interative, trial and error procedure, which would depend not only upon lagged demand responses but also on the willingness to change price frequently, which, in terms of administrative feasibility, Lewis considers as "the mother of confusion." However, he believes that if demand is good for water service, it will decide the contribution or allocation of corresponding charges.[21]

The foregoing analysis attempts to relate price theories to pricing policies of water utilities. However, before any conclusion can be reached, it should be emphasized that although the foregoing is a basic approach, many variations occur, specifically in terms of municipal ownership and economic circumstances surrounding each water utility. In contrast to private utilities, municipal water pricing will be more constrained by the political process, and prices may even be set below average costs with deficits financed from general tax revenues.

Pricing Theory for Agricultural and Industrial Water Uses

The discussion now turns to the pricing policy for water used in industry and agriculture. Apparently there has been special pricing

[21]W. Arthur Lewis, "The Two-Part Tariff," Economica (New Edition) Volume VIII, August 1941, p. 251.

treatment given to agriculture and industry due to their necessity in the production of goods and services. The demand for water in agriculture, relative to residential and industrial uses, is subject to greater seasonal variations. Lack of a relatively stable demand and low product returns per unit of water utilized necessitates a fairly high excess capacity of water supply which is a costly affair. For

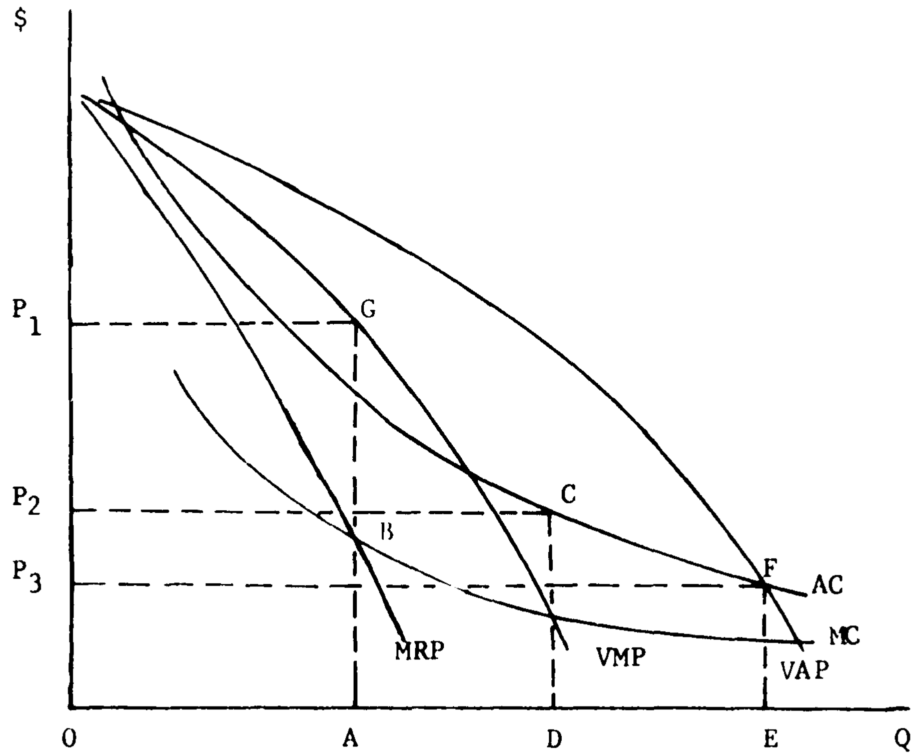

Figure 6: Pricing of Water for Agriculture and Industry

this reason, the water pricing policy in agriculture deserves special attention.

The case of agricultural water pricing is differentiated from residential and most industrial uses in that water is an essential productive input for agriculture and governs the returns and farm income generated from season to season. Some policies, such as crop-sharing, permit a direct relationship between the price charged for water and the farm returns associated with its use. In some cases, water prices are based on the ability to pay principle, specifically where irrigation projects were developed and financed by the U. S. Bureau of Reclamation. These variations will be discussed in more detail in the next section when different pricing policies will be examined for different climatic regions.

In Figure 6, the diagram shows a decreasing cost water system as one of Bureau's projects utilizing water from establishment of a dam on a river.[22] The value of the marginal product curve represents the effective demand curve for water by farmers. If the dam is regarded as a water firm and if the objective is to maximize profits, a storage capacity of OA will be constructed and the price charged for water would be equivalent to AG. This capacity, however, generates inefficiency in the allocation of resources since capacities beyond OA, the marginal cost of production is below the value of the marginal product of the water which can be provided by increased capacity. As a result an expansion of the project becomes necessary whereby larger volumes of water will be supplied by an increase in storage capacity.

The optimal size of the dam is OD where VMP=MC. However, it is not unusual to find that the Bureau of Reclamation establishes an uneconomic capacity (OE) where the value of the average product of water equals the average cost of the capacity. At this capacity (OE) however, the common

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[22] Julius Margolis, "Welfare Criteria, Pricing and Decentralization of a Public Service," Quarterly Journal of Economics, Vol. LXXI, No. 3, August 1957, pp. 449-451.

pricing policy of the Bureau is to charge farmers a price which is less than the average cost (AC) of production.

In the analysis of water pricing theory, the general situation appears to be one of monopoly power characterized by discriminatory pricing, with small volume consumers generally subsidizing large volume consumers, especially where declining block rate pricing prevails. This pricing policy leads to an inefficient allocation of water resources among different uses and users. Much of this results from economic and institutional barriers in the water market, created by government intervention in the provision and regulation of water supplying units.[23] Because of this, one questions what the history of water resources development and pricing would have been without government intervention. In other words, what would be the price situation if water prices were determined by the free forces of supply and demand in the water market? Undoubtedly, there would be more price fluctuations and the resource would not be labelled as a cheap commodity, since the consumer would pay in direct proportion to costs.

[23]Clayton K. Yeutter, Water Administration: A Suggested Institutional Model, (Lincoln: University of Nebraska), Department of Agricultural Economics Report No. 46, 1970, p. 17.

CHAPTER III

REVIEW OF WATER PRICING POLICIES IN ARID AND HUMID AREAS OF THE UNITED STATES

Water Rights Laws

The previous chapter dealt at length with price theory in an imperfect market, and its current role in the allocation of water resources. However, an additional element, which must be taken into consideration, is the influence of water rights laws on existing pricing policies and water resource allocation. Water rights introduce imperfection in the water market since such rights, normally, are not based on market forces, but rather on judicial interpretations and decisions. For this reason, a brief examination of water rights laws is included here to more completely explain the institutional water policies in the United States.

The legal complexities surrounding water resources stem from three interrelated factors which do not permit greater functioning of the price mechanism. These factors are: first, variation in the definition of property rights in the use of water; second, the public or private nature of agencies which make water use available; and third, public regulations governing the development of water resource projects. In any specific region, these factors have resulted in an interrelated maze of federal, state, and local laws which have created inflexibility, confusion, and conflicts in water use and pricing policies.

These same factors support the need for public intervention in providing water supplies and the centralization of decision making powers with respect to pricing policies. In this context, the Federal Government can be singled out, as the prime supplier of irrigation water without any national law governing the allocation or use of the water resource. With the possible exception of nuclear energy, no other basic resource is subject to more public and centralized control; and, no other resource is less subject to allocation through the market price system than the water resource.[1]

Generally, the Federal Government, exercises control over the development of the major river basins in the country, yet the distribution and use of such water is governed by state laws which regulate water services in the interest of safety and general welfare of the community. In view of this, social and economic considerations influence price policy since state water laws place primary reliance on judicial and institutional control of the resource.

The legal environment surrounding the use of water has emerged in two principal water doctrines, namely, the Riparian Doctrine and the Appropriation Doctrine, with the emergence of the latter originating from inequity and dissatisfaction expressed with the former. The

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[1] J. Hirshleifer, J. C. DeHaven, and J. W. Milliman, op. cit., p. 223.

Riparian Doctrine is based on the premise that the owner of riparian land has the right to take water from a natural water body bordering his land. It "grants riparian owners a right to have water flow by or through their lands undiminished in quantity, undisturbed in time of flow and unchanged in quality except for its use by upper riparian owners" for natural purposes (domestic use and watering of livestock).[2] This results in no priority over use since riparian owners only have usufructuary and not property rights. This interpretation was found to be somewhat restrictive, and the doctrine was therefore modified in most states to permit "artificial" uses, such as irrigation, contingent upon "reasonable" use. Lack of appropriate definition of what constitutes reasonable use has resulted in extensive court litigations and the development of the Appropriation Doctrine, or combinations of the two.

Unlike the Riparian Doctrine, the Appropriation Doctrine permits both riparian and non-riparian owners the right to use water, providing such use does not conflict with prior uses. It gives exclusive right on a priority basis, but use is conditional upon beneficial use, which in turn determines the continuation of such rights. The doctrine therefore is generally referred to as, "first in time, first in right" or better known as the "Prior-Appropriation Doctrine." Several modifications of this doctrine have occurred among states to meet specific needs in

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[2] Raleigh Barlowe, Land Resource Economics: The Political Economy of Rural and Urban Land Resource Use, (Englewood Cliffs: Prentice Hall, Inc.), 1960, p. 355.

the allocation of water resources. Generally, the Riparian Doctrine is found in the eastern states where water supplies are relatively abundant, while the Appropriation Doctrine, is more prevalent in the western states, where water supplies are normally considered scarce.

With this brief summary of the two basic water doctrines, attention is now directed to the examination of water pricing policies in the arid and humid regions of the United States. Due to the vagaries in the functioning of the hydrologic cycle, regional doctrines of water rights have developed. These in turn have led to different pricing policies, and the development of water institutions of a public and private nature. In this context, the use of irrigation water will be first reviewed, to be followed by residential and industrial water uses.

Agricultural and Industrial Water Uses

Arid Areas: In reviewing pricing policies in arid regions, emphasis is centered on the southwestern states, such as California and Arizona. Southern California is a good example of an area which has already experienced water deficits and salt water intrusion. Moreover, most of the water supplied is under contract at the wholesale level before it is marketed for final consumption. A unique feature, in the southern portion of the state is the transfer of water from the northern region and the additional importation of water from the Colorado River by means of aqueducts.

The pricing policies of water agencies in California vary by use, zone, season, and benefits received. Brewer indicates that five pricing methods can be differentiated:[3] (1) Postage Stamp Pricing where only one price is charged within a very limited area; (2) Differential Pricing where different prices are charged according to use; (3) Zonal Prices where prices differ by geographical or political boundaries; (4) Seasonal Pricing where rates vary depending upon the period within the year; and (5) Benefit Pricing where prices are based on benefits received through the use of given amount of water in a given period. These pricing policies are not mutually exclusive.

In California, pricing policies further depend on whether the supplier is a wholesaler and/or retailer of water, the type of ownership organization, and the source of water. For irrigation purposes, the Bureaus of Reclamation which was established in 1902 to serve the needs of the 17 western states, bases its policy on a contract cost-pricing standard, as stipulated in its repayment policy outlined in the Reclamation Act of 1902. This policy states that:

> It has been the philosophy of the Nation that all Reclamation costs for the purpose of irrigation and power and municipal and industrial water supply should be repaid in full. This has been expressed continuously as a requirement of Federal Reclamation laws enacted by Congress since

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[3] Michael F. Brewer, Economics of Public Water Pricing: The California Case, in Economics and Public Policy in Water Resources Development, Stephen C. Smith and Emery Castle (Eds.), (Ames: Iowa State University Press), 1964, p. 222-247.

> the passage of the original Reclamation Act of June 17, 1902... Repayment of all reimbursable project costs and operation and maintenance costs is a responsibility of the beneficiaries.[4]

Since 1902, several modifications of the Act have been made in the designated repayment period of the full reimbursable costs. Originally it was 10 years, but in 1914 it was extended to 20 years, and in 1926,40 years.[5] In 1939, however, the requirement of full payment was further modified and payments were based upon the ability-to-pay principle, as determined by water supplied for irrigation to an average farm through one of the projects of the Bureau. Davis and Hanke claim that, based on this latter principle, payments currently to the Bureau account for about 75 percent of the actual price of water.[6]

In order to combat the adverse effects of inflation and to make the ability-to-pay principle less burdensome to farmers, the Bureau permits repayment negotiations every five years within the 40 year contractual period. As a result, a "multi-component" pricing policy has emerged, depending upon the rate of inflation and the resulting

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[4] United States Department of the Interior, Reclamation Payments and Payment Schedules, (Washington, D. C.: United States Government Printing Office), 1965, p. ix.

[5] Michael F. Brewer, Water Pricing and Allocation with Particular Reference to California Irrigation Districts, (Berkeley: University of California), Giannini Foundation Report No. 235, p. 12.

[6] Robert K. Davis and Steve H. Hanke, op. cit., p. 16.

benefits from water supplied. In order to further make payment less painful, the Bureau also utilizes "differential pricing" based on the difference between available ground water and total water needs. When deficits occur, the supply of the Bureau is classified as Class I water for which a flat rate is charged; and Class II water is available only in surplus water years or early in the irrigation season and is lower in price than Class I. For example, Class II water is $1.50 per acre-foot in comparison to $3.50 per acre-foot for Class I water in the Central Valley Project in Southern California.

In addition to the Bureau of Reclamation, Bain et al, notes a series of other wholesale water agencies among which competiton and rivalry are common, specifically in the San Francisco Bay area.[7] The general pricing policy followed by these agencies, is based on average-cost pricing, through contracts, from which differential rates are developed in favor of water for agricultural use. Competition may or may not affect the price charged, and water is relatively cheaper in areas where the agency also provides electric power or receives financial assistance from public funds generated from land and property taxes.

Of special consideration in Southern California, is the importation of water by the Metropolitan Water District, for sale to retail

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[7]Joe S. Bain, Richard E. Caves, and Julius Margolis, op. cit., pp. 465-495.

agencies and replenishment of ground water supplies.[8] Adjudication of water rights with respect to ground water, is used to set production levels and ration existing supplies. An average of 130,000 acre-feet is purchased annually, and sold at a two-part price, depending upon water treatment performed. Hirshleifer et al., claim that softened Colorado water is sold at $25 and $22 per acre-foot, and untreated water, used specifically for agriculture, at $17 and $14 per acre-foot.[9] The average cost for unsoftened water is $28, and softened water at $36 per acre-foot. This policy of underpricing is, however, counterbalanced by supplementary revenues collected from taxes which range from $0.14 to $0.27 per $100 of all assessed land value. On the other hand, an additional tax of $3.90 per acre-foot is imposed on all ground water pumping.

At the retail level, water purchased from wholesale agencies is sold to irrigation districts and public utilities. With respect to irrigation firms, primarily cooperative organizations, their prices are composed of two parts: construction charges and operating charges. The construction charges are taxes assessed by the local district on farmers in the area, while operating charges are more commonly a tool

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[8]Laurence Falk, Economic Aspects of Ground-Water Basin Control, Louisiana Water Resources Research Institute, Bulletin GT-3, 1970, pp. 38-68.

[9]J. Hirshleifer, J. C. DeHaven, and J. W. Milliman, op. cit., p. 125.

or an assessment based on water use.[10] The construction assessment may be uniform per acre of land value, uniform per acre-foot of water estimated as needed, or variable per acre based upon the productivity of land and the ease of putting the water on the land. The operating charges are more commonly covered by a uniform charge per acre-foot of water. In all cases, the price charged at the retail level for agricultural water is designed to cover the average costs associated with a given supply.

Variations in this pricing policy, however, are not uncommon. For example, the toll may not be levied where districts acquire sufficient revenues from the sale of hydroelectric power; or it may be set to cover only the wholesale price of water. Occasionally it may be set at a level to cover the costs of pumping in order to discourage the use of ground water; or it may vary within a season by charging a lower price in the early part of the season, or it may vary with type of crop grown, such as higher rates for rice, a voracious water user.

In California and Utah, Hutchins noted another policy being followed by private mutual irrigation water companies. These companies issue shares entitling the owner to a portion of water held by the company through its water rights.[11] A toll is levied on each share to

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[10] Julius Margolis, _op. cit._, p. 453.

[11] Wells A. Hutchins, _Mutual Irrigation Companies in California and Utah_, U. S. Farm Credit Administration, Cooperative Research Division, Bulletin No. 8, 1966, p. 35.

liquidate the operating expenses of the company and this constitutes the price of water for irrigation. In the South Platte Basin, however, companies have developed a rental procedure for seasonal transfer of irrigation water to accomodate the varying needs of users.[12] In dry years, more transfers occur because of shifts from low return users on some farms to high return users on others. In 1959, prices of rental water ranged from $2.50 to $8.00 per acre-foot. During the dry years, the price may reach $30 per acre-foot, but community pressures generally keep prices lower than this.

In arid Arizona, where crop irrigation accounts for 90 percent of total water use, and where an annual deficit of 3.5 million acre-feet is realized by excessive use of ground water, the Central Arizona Project was developed to import 1.2 million acre-feet annually from the Colorado River.[13] Water delivered to the Project costs between $25 to $30 per acre-foot, but farmers are charged $10 per acre-foot while municipalities and industrial plants are charged $50 per acre-foot.[14] These figures do not include an average cost of $5.50-$7.83 per acre-foot to transport water from the Project to the consumer. When this

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[12] Raymond L. Anderson, "Operation of the Irrigation Water Rental Market in South Platte Basin," Journal of Farm Economics, Volume XLVII, No. 5, December 1960, pp. 1501-1502.

[13] William E. Martin and Leonard G. Bower, "Patterns of Water Use in Arizona Economy," Arizona Economic Review, Volume 5, No. 12, December 1966, p. 4.

[14] Robert A. Young and William E. Martin, "The Economics of Arizona's Water Problems," Arizona Economic Review, Volume 16, No. 3, March 1967, pp. 9-18.

is included, the average total cost ranges from $30.57-$37.83 per acre-foot. Water from local irrigation wells is estimated to cost $15 per acre-foot. Farmers are able to obtain cheaper water because the difference is made up from higher prices to municipal plants and by revenues gained from property taxes.

Humid Areas: Humid areas have more abundant water supplies than arid areas, hence water for agricultural use is generally obtained from locally developed sources. In some semi-humid regions, where large federal irrigation projects exist, water is supplied at a relatively cheaper price than in arid regions where supplies are generally considered to be relatively scarce.

In the semi-humid Rio Grande Valley of Texas, where both the Appropriation and Riparian Doctrines coexist, Casbeer and Trock noted that a variety of agencies, both federal and state, are providing agricultural water, the most important agencies being the irrigation and drainage districts which supply about 90 percent of the water.[15] At the federal level is the Bureau of Reclamation whose pricing policy has been discussed in the section dealing with arid lands. At the state level, irrigation districts supplying water on contract

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[15] Thomas J. Casbeer and Warren L. Trock, A Study of Institutional Factors Affecting Water Resources Development in Lower Rio Grande Valley, Texas, (College Station: Texas Agricultural Experiment Station), Technical Report No. 2, 1968.

charge only a pumping fee ranging from \$0.02-\$0.04 per 1,000 gallons, contingent upon distance pumped. Water sold to public utilities are charged a similar price. Water for lawns, however, is acquired directly from the districts at a lower price through district canals which serve the cities in the area.

The Water Control and Improvement Districts, another source of water supply, base their pricing policies upon revenues required to cover maintenance and operation costs and for the payment of interest on any fixed obligations. These revenues are acquired through: (1) An unlimited ad valorem tax on all real and personal property within the district; (2) A flat charge or toll per acre of assessed irrigated land; and (3) A direct charge for water delivered to the farm. Taxes are also used for partial liquidation of the district's variable costs and are collected whether water is used or not. These taxes, at the rate of \$0.42 per 100 of assessed property value, range from \$2.00 to \$6.25 per acre with an average of \$3.25. Some districts have a special bond tax to retire any bonded indebtedness. The flat charge ranges from \$1.00 to \$5.00 per acre and is levied each time water is delivered.

In the Rio Grande Valley, specific allotments of water for irrigation are made by the Board of Directors in each of the 34 Water Control and Improvement Districts. Portable water meters are used to measure the amount of water supplied to farms. However, there is no restriction on the quantity delivered and a flat charge is imposed ranging from \$1.25 to \$2.00 per acre foot.

In total, the toll plus taxes generally average about $10.00 per acre-foot of water. However, Willie Ulich in his study of the Southern Plains of Texas found the price charged for water ranged from a minimum of $1.82 to a maximum of $72.76 per acre-foot with an average of $15.61.[16] These variations are not unusual as the price of water depends upon availability of water supplies and the type of agencies which supply it.

In the humid area of Northeastern United States, water is provided by the Delaware River Basin Commission to the adjacent states of Pennsylvania, New Jersey, New York, and Delaware.[17] Projects within the jurisdiction of the Commission are developed by the Corps of Engineers, through federal funds repaid on a pay-as-you go basis, and with cost allocations shared in proportion to benefits received. Water is sold on a negotiable contract with a minimum charge levied regardless of use, withdrawal or diversion. Specific reduced rates apply to water used in cooling processes, providing such water is returned unimpaired in quantity and quality. Where this is not so, effluent charges are imposed on discharges in proportion to pollution costs incurred.

The fundamental premise of the Commission's pricing policy is based on a weighted average cost of surface water stored in its

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[16] Willie Ulich, "Efficiencies and Costs of Pumping Irrigation Water on the Southern Plains," Proceedings of the Seventh West Texas Water Conference, (Lubbock, Texas), February 1969, p. 48.

[17] Annual Report, 1971, Delaware River Basin Commission, (Trenton, New Jersey), p. 48.

reservoirs. A significant feature of this average cost pricing policy is the fact that it is based on incremental or marginal cost pricing which implies that water facilities are developed to the point of an optimum rate of output or scale of production where both the average and marginal costs of production are equal.[18] Deviations from this optimum, as economic theory dictates, result in average costs greater or less than marginal cost, so this method of pricing not only permits the most efficient plant size, but also requires consumers to pay according to cost of incremental units of water supplied.

On the basis of this pricing policy, three different rates have been established by the Commission. First, there is the basic or general service rate which is set at a level "to provide sufficient revenues to meet annual project costs of debt service, operation, maintenance, and replacement costs, financial reserves, and all other charges, assuming no reuse or resale of the same water."[19] Second, there is an annual adjusted rate which takes the form of a rebate to each user, depending upon surplus earnings of the Commission during a given year. Third, a charge is imposed for water consumed in industrial processes, or exported from the reservoirs of the Commission.

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[18] Delaware River Basin Commission, Charges to Users of Water Supply from Projects in the Commission's Comprehensive Plan, (Trenton, New Jersey: Staff Paper No. 20), August 1970, p. 4.

[19] Ibid., pp. 4-5.

In Kansas, the Bureau of Reclamation's pricing policy is based on the economic ability of farmers to pay for irrigation water. This policy is also used by the state government in projects developed entirely with funds allocated by the state legislature.[20] As mentioned previously, this ability to pay pricing policy only accounts for 75 percent of the actual cost of water, with the difference, in the case of Kansas, being recovered from revenues obtained through the sale of hydroelectric power from the Missouri River Basin.

In contrast to the Bureau of Reclamation, the Corps of Engineers does not impose a charge for irrigation water supplied through the Flood Control Act of 1960.[21] Instead, cost-sharing is the common practice with the share paid by the Federal Government not to exceed 70 percent of the "total first costs" of any project. Local interests share the remaining 30 percent which is supposed to cover land-oriented costs such as easements, rights of way, and reallocations. When this latter percentage is not achieved, local interests are required to make up the difference by contributing to construction costs also. However, for municipal and industrial users, all costs must be fully reimbursed, including interest charges.

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[20]Kansas Water Resources Board, State Water Policy and Program Needs: A Report to the 1961 Kansas Legislature, November 1960, p. 28.

[21]United States Department of Agriculture, A History of Federal Water Resources Programs 1800-1960, (Washington, D. C.: United States Government Printing Office), Miscellaneous Publication No. 1233, 1962, pp. 36-37.

Table 4, outlines a series of charges paid by farmers for water in 22 states in the nation. In attempting to give some kind of interpretation to the charges within the respective states, it must be borne in mind that, generally, the eastern states are well supplied with water in comparison to the western states. Moreover, it should be noted that the northwestern states are relatively better supplied than the southwestern states where serious water deficits have already occurred in areas of Southern California, Arizona, and Texas. Because of shortages in supply, the prices paid for water tends to be highest in states such as California, where the highest average price of $31.37 per acre-foot was reported. This average disguises the fact that in northern California prices average about $5.88 per acre-foot while in southern California, current price estimates range between $30-$60 per acre-foot of water.

In the eastern region, water prices are generally negotiated or contracted as a share of the crop, such as in Illinois. Swanson notes, in contrast to Louisiana where charges for water represent a direct share of the rice crop, the charge for water forms part of the entire share of the crop, i. e., water in combination with other inputs provided by the landlord.[22] This ranges from one-third to one-half of the crop in comparison to Louisiana where the share is normally considered to be one-fifth of the rice crop. Corty estimated that

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[22]Earl R. Swanson, Economic Analysis of Water Use in Illinois Agriculture, (Urbana: Water Resources Center, University of Illinois), Research Report No. 38, January 1971, p. 51.

Table 4. Average Prices Paid by Farmers Per Acre-Foot of Water in 22 States, 1972 1/

State	Dollars per acre-foot	State	Dollars per acre-foot
Texas	8.28	Montana	2.54
New Mexico	7.36	Kansas	8.42
Arizona	7.86	North Dakota	3.72
California	31.37	South Dakota	2.21
Nevada	6.61	Nebraska	4.09
Utah	3.02	Illinois	3.05
Colorado	2.40	Oklahoma	6.67
Wyoming	2.52	Minnesota	3.06
Idaho	2.74	Iowa	5.76
Oregon	2.86	Missouri	5.47
Washington	2.78	Arkansas	6.68

1/ Computed from data in: Earl O. Heady, Howard C. Madison, Kenneth J. Nichol, and Stanley H. Hargrove, Agricultural and Water Policies and the Environment, Ames: Iowa State University, 1972, p. 76.

this crop-sharing pattern may amount to between \$15-\$42 per acre for water supplied by water canal companies in the Louisiana rice area.[23] Based on an average use of 1.02 million gallons of water per acre, this charge is equivalent to a range of \$4.80 to \$13.45 per acre-foot of water.

Residential Water Use

In early times, charges for water service represented a flat charge which was based on certain physical characteristics of the consuming unit, such as the number of faucets or bedrooms in terms of residential use, or the volume and nature of the product in industrial water use. With the introduction of water meters, refinements were made in developing rate structures and policies aimed at a more equitable cost allocation according to demands placed on the system by each customer class. This does not infer that flat rates have completely vanished for they still exist in some parts of the nation. In Louisiana, as reflected by this study, 34 percent of the water utilities (mostly small plants) still use such a system.

Arid Areas: With respect to public water systems, the most common pricing practice in Nevada, Utah, Arizona, and Southern California is the declining block rate method coupled with a minimum charge which is not tied to the volume of water allocated in the first block. Table 5 shows the average charges for water service in four selected cities serving populations over 10,000 in Nevada, Utah, Arizona, and Southern California. Analysis of this table indicates

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[23] Floyd L. Corty, Leasing Farm Land for Rice Production, (Baton Rouge: Louisiana Agricultural Experiment Station, D.A.E. Research Report No. 383), 1968, p. 11.

Table 5. Average Monthly Water Rates in Four Selected Cities of Over 10,000 Population in Nevada, Utah, Arizona, and California (20 inches or less rainfall), 1960

Item	Nevada	Utah	Arizona	Southern California
Minimum charge per month, dollars	3.32	2.13	2.88	1.63
Allowance in minimum gallons per month	22,000	9,700	8,250	4,500
Charge per 1,000 gallons in minimum, dollars	0.15	0.22	0.35	0.36
Metered rates, monthly per 1,000 gallons				
3,750 gallons monthly per 1,000 gallons	0.95	0.54	0.72	0.47
7,500 gallons monthly per 1,000 gallons	0.58	0.36	0.40	0.38
75,000 gallons monthly per 1,000 gallons	0.20	0.20	0.22	0.32
750,000 gallons monthly per 1,000 gallons	0.17	0.19	0.18	0.25
Fire protection charges, dollars per year per hydrant				
Public	32	25	47	34
Private	60	30	48	48
Rates for outside-limits customers (percent above inside-limits)	--	60	72	60

Source: Extracted from: A Survey of Operating Data for Water Works in 1960, Staff Report, New York: American Water Works Association, 1964.

that although Nevada permits a monthly average of 22,000 gallons in the minimum charge of \$3.32 per month, the price per 1,000 gallons is less than half that of Arizona and Southern California where the minimum is 8,250 gallons and 4,500 gallons, respectively. However, within the first block, the price charged by Nevada is double that of California.

The fundamental premise of declining block rates is to charge a lower rate as the volume sold in each block increases. For this reason water utility price analysts normally compare the ratio of the charge of the first and last blocks within a given rate schedule to determine the degree of difference between these two blocks. For Nevada this ratio is about 5.6, Utah 2.8, Arizona 4.0, and Southern California 1.9. These ratios indicate that the difference in charges between the first and last blocks is greatest in Nevada and smallest in Southern California.

From this table, one may be puzzled by the low rates for water service by cities in Southern California where water deficits have already occurred. The fact is that the resulting deficit from the underpricing of water, is recovered through ad valorem taxes. The data in Table 6 show this difference for water purchased from the Metropolitan Water District and sold by the city of Los Angeles in 1957.

In Los Angeles, the underpricing of residential water, not to mention the more favorable prices accorded to agriculture, led Hirshleifer et al to state that "water rates at the retail level in Southern California are lower than those found in many parts of the

United States."[24] This is rather ironical when one takes into consideration that Southern California is one of the areas of the United States facing a most critical water shortage and water has to be imported from the Colorado River, some 200 miles away.

Table 6. Calculated Purchase Prices and Selling Prices of Water by the City of Los Angeles, 1957

Volume	Purchase price per acre-foot	Selling price per acre-foot
Gallons	- - - - - - - - - Dollars	- - - - - - - - -
7,500	88	74
75,000	64	59
750,000	50	46
7,500,000	45	43

Source: Jack Hirshleifer, James C. DeHaven, Jerome W. Milliman, Water Supply: Economics, Technology, and Policy, Chicago: The University of Chicago Press, 1960, p. 304.

Further, pricing policies and levels of rate structures vary considerably in other parts of the arid areas of the United States. Cochran and Wilson found in southern Nevada that the Las Vegas Valley District, which supplies water at the wholesale and retail levels,

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[24] Jack Hirshleifer, James C. DeHaven, and Jerome W. Milliman, op. cit., p. 304.

charges a minimum of $3.85 per customer and a uniform rate of 19 cents per 1,000 gallons per month for residential water.[25] However, in northern Las Vegas, the minimum charge is practically double that amount, with rates ranging from 77 cents down to 21 cents per 1,000 gallons per month.

Boulder City, Nevada, is rather unique with respect to mimimun charge and water rates since they are lower for residential customers than for other users.[26] For example, the minimum charge for domestic use in $3.00 per month and price per 1,000 gallons is 12 cents while commercial users pay a minimum ranging from $6.00 to $216.00 and a price of 12 cents per 1,000 gallons per month. On the other hand, Henderson City, Nevada, which purchases water for resale to residential customers, sets the price per thousand gallons at less than its cost, and the price favors commercial users. The average cost of water per 1,000 gallons was estimated at 27.8 cents, but was sold at an average price of 23 cents, with the difference provided by a subsidy from the city government.

In Boulder, Colorado, Hanke noted that a "two-part tariff", is used with fixed minimum charges based on meter size and a declining rate charge.[27] Actually, there are only two blocks; one of these in-

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[25]G. H. Cochran and W. C. Wilson, Arid Urban Water Management: Some Economic, Institutional and Physical Aspects, (Reno, Nevada: Desert Research Institute), Publication No. 11, 1971, pp. 9-13.

[26]Ibid.

[27]Stephen H. Hanke, The Demand for Water Under Dynamic Conditions: A Case Study of Boulder, (Fort Collins, Colorado: Unpublished Ph. D. Dissertation, University of Colorado), 1969, p. 93.

cludes the minimum, and the price charged for the additional block is 35 cents per 1,000 gallons per month. The city's water utility also charges a "plant investment" or tapping fee which ranges from $300 for a three quarters of an inch meter size to $8,400 for a five inch meter size. Water provided for public use to city agencies and departments for cleaning and sprinkling, is free of charge.

Humid Areas: In humid areas, pricing policy for residential water use appears to be no different from that in arid areas for as Tables 7 and 8 indicate for selected cities in the states specified, the declining block rates coupled with a minimum monthly charge are common in all the states surveyed. With respect to the level of rates, there are slight variations, with the state of Washington having the lowest rates per 1,000 gallons per month. A significant difference between the arid and humid areas lies in the volume of water allowed under the minimum monthly charge. On the average, the minimum charge is about two times greater in the arid than in the humid areas. With respect to fire protection, rates charged by publicly owned water utilities are sometimes less than utilities that are privately owned as would be expected. Rates for water service to residents living outside city limits are higher than those within city limits in all regions. In fact, outside rates were about twice the inside rates in the states of New York and Mississippi.

Since this study relates mainly to Louisiana, a more detailed comparison of rates of the selected cities in Louisiana, with the selected cities of the eleven states specified is warranted. As Tables 5, 7, and 8 indicate the monthly minimum charge per 1,000

Table 7. Average Monthly Water Rates in Four Selected Cities of Over 10,000 Population in Washington, Oregon, Louisiana, and Mississippi (over 50 inches rainfall), 1960

Item	Washington	Oregon	Louisiana	Mississippi
Minimum charge per month, dollars	1.06	1.84	1.13	1.88
Allowance in minimum gallons per month	3,000	2,625	3,900	3,300
Charge per 1,000 gallons in minimum, dollars	0.35	0.71	0.30	0.57
Metered rates, monthly per 1,000 gallons				
3,750 gallons monthly per 1,000 gallons	0.30	0.60	0.52	0.51
7,500 gallons monthly per 1,000 gallons	0.24	0.43	0.35	0.43
75,000 gallons monthly per 1,000 gallons	0.17	0.24	0.30	0.26
750,000 gallons monthly per 1,000 gallons	0.13	0.14	0.20	0.17
Fire protection charges, dollars per year per hydrant				
Public	--	--	--	48
Private	--	--	--	50
Rates for outside-limits customers (percent above inside-limits)	61.0	63.0	42.0	100.0

Source: Extracted from: A Survey of Operating Data for Water Works in 1960, Staff Report, New York: American Water Works Association, 1964.

Table 8. Average Monthly Water Rates in Four Selected Cities of Over 10,000 Population in Indiana, Ohio, Pennsylvania, and New York, (30-49 inches of rainfall), 1960

Item	Indiana	Ohio	Pennsylvania	New York
Minimum charge per month, dollars	2.07	1.13	1.12	1.24
Allowance in minimum gallons per month	3,600	3,000	1,500	2,850
Charge per 1,000 gallons in minimum, dollars	0.58	0.38	0.75	0.44
Metered rates, monthly per 1,000 gallons				
3,750 gallons monthly per 1,000 gallons	0.60	0.40	0.47	0.36
7,500 gallons monthly per 1,000 gallons	0.55	0.36	0.40	0.36
75,000 gallons monthly per 1,000 gallons	0.44	0.34	0.30	0.30
750,000 gallons monthly per 1,000 gallons	0.26	0.23	0.23	0.27
Fire protection charges, dollars per year per hydrant				
Public	50	40	35	55
Private	55	--	27	55
Rates for outside-limits customers (percent above inside-limits)	62.5	76.0	15.0	100.0

Source: Extracted from: A Survey of Operating Data for Water Works in 1960, Staff Report, New York: American Water Works Association, 1964.

gallons of water in the four selected cities of Louisiana ($0.30) is exceeded in 10 states and lower only in the cities of Nevada and Utah. However, when metered rates based on the declining block method are compared with these two latter states, the rates in the four Louisiana's cities are lower in every block with the exception of the third and fourth blocks. These exceptions, however, are insignificant as far as residential water use is concerned for they relate to a monthly consumption of 75,000 gallons or more. Very few, if any, residential customers consume such volumes of water on a monthly basis. These large volume blocks are primarily designed to meet the needs of large establishments such as commercial and industrial enterprises.

A more meaningful comparison of the selected cities of Louisiana with those of other states is the monthly charge per residential customer based on an assumed consumption of 10,000 gallons per month (Table 9). On this basis, an average for the four Louisiana cities rank seventh among the cities of the 12 selected states. However, one may question why the cities of the states of Nevada and Utah have a lower monthly charge for domestic water than the cities of Louisiana, since their metered rates are higher than the latter. The explanation lies in the fact that the volume of water allowed in the minimum is about five times greater in Nevada, and three times higher in Utah than in Louisiana, despite the fact that the minimum charge in the Louisiana cities is less than half that charged in Nevada and Utah. A revealing situation from Table 5, is that in arid areas where water is considered relatively more scarce than in humid areas, prices charged per 10,000 gallons per month, are lower in the former, with the only exception being California.

Table 9. Average Monthly Charge for 10,000 Gallons of Water in Four Selected Cities With Over 10,000 Population in Each of 12 States, 1960

State	Monthly charge per 10,000 gallons
	Dollars
Oregon	5.83
Indiana	5.79
Mississippi	5.08
Pennsylvania	4.80
California	4.11
Washington	3.98
Louisiana	3.91
Arizona	3.90
Ohio	3.81
New York	3.76
Utah	2.31
Nevada	1.66

Source: Computed from data provided in Tables 5, 7, and 8.

Based upon this review of pricing policies of water in arid, humid, and semi-humid regions of the United States, it is evident that hydrologic and climatic differences among these regions generate tangible evidence of effects of natural supplies upon a general pricing policy. In addition, other factors influence the determination of a specific pricing policy. These factors although difficult to delineate or identify, include: size and nature of population served, the purpose for which water is used, type of ownership of water agencies, distance over which water is to be transported, the economic ability of water consumers to pay for water, and the role of the political machinery in water resource development.

With respect to water allocated for agricultural use, it is apparent that pricing policies differ across the nation, with the possible exception of areas served by the Bureau of Reclamation whose policy is based primarily on the economic ability of farmers to pay for water used. Farmers are subsidized directly by water supplied from the projects of the Bureau. Outside the Bureau, the level of rates vary, but on most occasions these rates are not designed to cover the average costs of providing a given supply.

Water for agricultural use is generally underpriced and, where its price fails to recover average costs, the difference is derived from public funds, normally generated by the imposition of taxes on land and other property. In some cases the difference may be recovered by direct grants of public funds by the local government or from revenues collected from residential and industrial water customers. For this reason

McGauchey and Erlich claim that the price of agricultural water is not related to its costs since it is determined after all agricultural production costs, except water, have been met.[28]

Relative to water delivered by utilities for residential and industrial uses, the most common pricing policy, irrespective of climatic differences among the regions, is the declining block rates coupled with a minimum monthly charge. However, a survey by the American City Magazine in 1970, indicated that only 85 percent of the utilities in the United States use declining block rates.[29] This was also borne out by the surveys of Keig et al,in the same year[30] and that of the American Water Works Association in 1960.[31]

In contrast to agriculture, the common pricing policy followed by water utilities in supplying water for residential use, is that rates are designed to cover the average costs of production, i. e., an average cost pricing approach. This is the general policy outlined in

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[28] Paul H. McGauchey and Harry Erlich, "Economic Evaluation of Water," American Society of Civil Engineering Proceedings, Journal of Irrigation and Drainage Division, Volume 85, No. IR-2, June 195, pp. 1-21.

[29] "Modern Water Rates," American City Magazine, November 1971, p. 66.

[30] Norman G. Keig, Charles W. Fristoe, and Frederick O. Goddard, "Rate Making Policies and Practices of Utilities," Journal of American Water Works Association, Volume 62, No. 7, July 1970, p. 425.

[31] A Survey of Operating Data for Water Works in 1960, Staff Report, (New York: American Water Works Association, 1964).

the Water Rates Manual of the American Water Works Association,[32] and Keig et al, found that 98 percent of the utilities' executives in the United States agree with this principle.[33] However, Afifi and Bassie found that 80 percent of the utilities use this approach in Illinois, and about 12 percent use the marginal cost pricing approach.[34] This latter policy reflects a very important step forward in terms of water pricing from the standpoint of efficient allocation of water resources. It should be noted, however, water utilities operating under decreasing costs conditions, a price based on marginal cost will fail to recover the average cost of production. In such cases some form of deficit financing has to be provided or water utilities may be forced out of business.

[32] Water Rates Manual, 2nd Ed., (New York: American Water Works Association), 1972, p. 1.

[33] Normal G. Keig, op. cit., p. 425.

[34] Hamdy H. H. Afifi and V. Lewis Bassie, Water Pricing Theory and Practice, (Urbana, Illinois: University of Illinois Bulletin), Volume 66, No. 142, July 1969, p. 153.

CHAPTER IV

ECONOMIC CHARACTERISTICS OF RESIDENTIAL WATER SUPPLIERS

As discussed in Chapter II, the residential water market is characterized by a series of imperfections which have resulted in monopoly power by water utilities but with this power subjected to government control through the regulation of water rates. The two characteristics of monopoly power and government regulation bear directly on the costs of water supplies, the structure of water rates, the pricing policy of water utilities and the financial solvency. In view of the importance of these two characteristics, it is necessary to examine their influence with respect to: (1) organization of water utilities, (2) demand for residential water, and (3) supply of residential water

Organization of Water Utilities

Monopoly Status: The residential water market most often conforms to pure monopoly where a single water utility is producing a product (water) for which there are no close substitutes. Because of the economic and social nature of water service, water utilities are generally accorded a status of a "legal" or "natural" monopoly.

The existence of a natural monopoly is based on two conditions: (1) the water utility incurs increasing economies of scale over a wide range of output so that a single water utility can supply the market more efficiently than two or more water utilities; and (2) unrestricted competition among water utilities is regarded as undesirable by society. As a result water utilities are given an exclusive right or a special charter to operate by government who in return regulate their level of rates and quality of service.

The first condition of increasing economies of scale is primarily a technological one that characterize water utilities. The technology of water utilities is such that once the fixed capital investment in facilities such as storage tanks, water mains and the purification plant are established, additional customer service will result in a decline in average total costs of production over a wide range of output. For this reason the monopoly status of water utilities is regarded as the most efficient method of providing water service without regard to the system of distribution.[1] Competition among water utilities engenders unnecessary duplication of capital facilities and right-of-way conflicts in the distribution of water mains by more than one water utility in a community. The lack of competition has fostered either government regulation or the ownership of water utilities in order to avoid the exercise of monopoly power specifically in relation to their earnings.

The second condition of social undesirability of unrestricted competition stems from welfare considerations of the community

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[1]Leonard W. Weiss, op. cit., p. 225.

specifically with regards to health and fire protection. The health of an entire community can be adversely affected by poor water quality. Similarly, the economic welfare of the citizenry can be destroyed if an adequate amount of water is not available to combat outbreaks of fire. An adequate supply of water therefore necessitates some manner of control consistent with the safety and health of a community and consequently makes monopoly and governmental regulation or ownership integral elements in residential water supplies.

According to Eustler, water utilities in the United States are predominatly publicly owned due to their monopoly status.[2] In Louisiana, however, as reflected by this study, 44 percent are publicly owned (municipal water utilities) while 35 percent are privately owned. The remainder of the water utilities (21 percent) are operated by a group of citizens as nonprofit corporations financed by funds provided by the Farmers Home Administration.[3]

Public ownership of water utilities have been critized as lacking incentive to achieve economic efficiency. This may account for the characteristic underpricing policy of water which engenders deliberate

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[2]Roland B. Eustler, "Public and Private Ownership of Water Supply Utilities," The Annals of the American Academy of Political and Social Science, Vol. 201, January 1939, pp. 89-95.

[3]These water utilities will be referred to as FHA water utilities in this study.

waste and misallocation of the resource. Kenneth Boulding, a firm believer in the system of private enterprise claims, "of all the easily recognizable physical commodities, water seems the one we are least willing to leave in private hands . . . (and) we would be better off if the state had never intervened in the supply of water, or even if the municipality in general did not feel obligated to take on this enterprise.[4]

Ownership and Pricing Policy: There is some difference of opinion as to whether there should be any distinction between publicly and privately owned water utilities, specifically with respect to pricing structure and policy. Some experts claim there should be no difference whatsoever since water utilities perform similar functions and provide identical services to the community.[5] However, the argument persists, and some sociologists maintain, that, since water is a basic commodity for human survival, its price should be geared to the budget of even the poorest members of the community. This latter argument is weak, since water is an economic good and is in no way different from other commodities necessary for human survival.

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[4]K. Boulding, "The Economist and the Engineer; Economic Dynamics of Water Resource Development," in Stephen C. Smith and Emery M. Castle (Eds.), Economics and Public Policy in Water Resources Development, (Ames: Iowa State University Press), 1965, p. 86.

[5]Timothy Brown, "Wisconsin Policies on Water Works Funds," Journal of American Water Works Association, Volume 41, No. 8, August 1949, p. 822, and Orville P. Deuel, "Water Utility Rate Making, "Journal of American Water Works Association, Volume 58, No. 7, July 1966, p. 845-848.

In Louisiana, legal jurisdiction over pricing policy and rate levels is exercised by different groups of individuals or institutions according to ownership of the utility. The Louisiana Public Service Commission regulates private water utilities, the Farmers Home Administration controls the rural nonprofit corporate water utilities, and the respective local governments exercise complete jurisdiction over those municipally owned. Within the latter group, pricing policy is solely in the hands of governing bodies such as a board of aldermen or water commissioners. Table 10 shows the regulating authority over water utilities in Louisiana as reflected in the survey. Data in Table 10 indicate that 35.3 percent of the water utilities are under the surveillance of the Louisiana Public Service Commission, i. e., they are privately owned water systems.

Table 10. Authority Regulating Water Utilities in Louisiana, 1971

Regulating authority	Number of utilities		Actual percent
	Sample	Actual	
Public Service Commission	112	112	35.3
Farmers Home Administration	65	65	20.5
Municipal Governments:			
Mayor and Council	38	98	30.9
Mayor and Board of Alderman	7	18	5.7
Board of Commissioners	7	18	5.7
Police Jury	2	6	1.9
Total	231	317	100.0

The Farmers Home Administration, as the financing agency for rival water systems, regulates about one-fifth of the water utilities. On the other hand, municipal governments regulate 42.3 percent of all water utilities and also control the greatest volume of residential water in Louisiana. The regulatory power of these municipal water utilities, however, may be vested directly in the mayor and the municipal council or some appointive body such as a Board of Aldermen, or a Board of Commissioners.

The Louisiana Public Service Commission has no fixed pricing policy for privately owned water utilities. Each utility proposing a rate schedule or rate revision is considered individually, based on evidence relating to the revenue requirements of the respective utility. As one official of the Commission puts it, "a determination is made as to the income necessary to operate the system (water utility) and provide a fair rate of return." The rate schedule is designed to accomplish this objective.[6] In water utility literature, this method of determining rate schedule and revenue requirements is referred to as the "Utility Basis."[7] In economics it is known as the "fair-return price". This procedure is also used by the FHA in determining the rate schedules of water utilities under their jurisdiction.

The publicly owned water utilities in Louisiana on the other hand,

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[6] Personal letter from Chief Accountant, Louisiana Public Service Commission, Baton Rouge, Louisiana.

[7] <u>Water Rates Manual</u>, 2nd Edition, (New York: The American Water Works Association), 1972, p. 1-4.

use the "Cash or Budget Basis" in which revenue requirements, via rate schedules, are not tied to a fair return on investment, but instead on the cash or budget requirements for the current operation of the water utility, based on local conditions and policies.[8] Because public utilities are normally financed by municipal governments, the use of the cash basis appears more realistic when one takes into consideration that public utilities are not profit oriented. The cash basis is similar to the budget of other municipal departments, and as such, is more easily explained and justified to public or municipal administrations. The total revenue needed is based on detailed estimates of cash requirements supported by operating experience and knowledge of immediate future needs.

Based on these two pricing policies, it appears that for privately owned water utilities the objective is to obtain a "fair rate of return on investment." However, an additional element to be considered in order to distinguish revenue requirements of both types of ownership is the imposition of the income tax or property tax on private utilities and not on public utilities. Therefore, in the determination of pricing policy and rate levels, the revenue requirements of a private utility would exceed those of a publicly owned utility by the sum allocated to taxation plus a fair return on investment. Accordingly, rate levels ascribed to privately-owned utilities were found to be relatively higher than for publicly owned utilities. Based on data of this study,

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[8] Ibid.

the price charged by private utilities for 10,000 gallons of water averaged $7.90. For municipally owned utilities the price charged was $6.74 and FHA water utilities $10.08. The lower average price charged by municipal water utilities, as shown later is reflected through their lower average costs of production.

Demand Characteristics

Market Size: The market served by water utilities is local in nature and influenced to a large extent by the demand for residential water. Generally, as the population increases the demand for water increases. Afifi ranks population as the major determinant of market size and future growth of water utilities, followed by economic activity, family income and water rates, respectively.[9] The rationale for this conclusion stems from the fact that since water is a basic economic good without any socially acceptable substitutes, its' role in human survival and economic expansion hardly needs to be emphasized. Therefore, as population increases, not only does total water consumption increase, but one can also expect an increase in consumption on a per capita basis. This latter increase may be attributed to improved family incomes and increased economic activities such as more water using appliances, more garden sprinkling, air-conditioning and automobile washing.

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[9] H. H. H. Afifi, Economic Evaluation of Pricing Water Supply in Illinois, Unpublished Ph. D. Dissertation, (Urbana: University of Illinois), 1967, p. 21.

Currently, local water markets facing the majority of water utilities in Louisiana are relatively small. As seen from Table 11, 44.6 percent of the water utilities served a population of 500 or less and 68 percent served about 1,000 persons or less. Based on the assumption of an average family size of four, this implies that these water utilities serve about 125 and 250 families, respectively. A possible explanation for this situation is that entry to the residential water market is relatively easy due to readily available water supplies in practically every region of the state.

Table 11. Distribution of Water Utilities by Population Served in Louisiana, 1971

Population served	Number of water utilities		Adjusted
	Sample	Actual	percent
1 - 500	103	141	44.6
501 - 1,000	54	74	23.4
1,001 - 3,000	27	37	11.7
3,001 - 5,000	12	16	5.2
5,001 - 10,000	10	14	4.3
10,001 - 15,000	7	10	3.0
15,001 - 25,000	4	5	1.8
25,001 - 50,000	7	10	3.0
Above 50,000	7	10	3.0
Total	231	317	100.0

Apart from serving residential customers, about 10 percent of the water utilities surveyed also serve commercial and industrial customers.

These customers generally pay the same rates as residential customers, but in a technical sense these commercial and industrial customers are favored by price discounts for the larger volumes of water purchased. This is an inherent feature of "declining block rate" schedules which are commonly used by the larger water utilities.

On the basis of this Louisiana survey, consumption per capita in 1971 was estimated at 84 gallons per day. The Gulf South Research Institute, which surveyed municipal water utilities located primarily in urban areas, estimated an average of 132 gallons per capita per day.[10] The American Water Works Association, which surveyed water utilities serving populations of 10,000 or more in Louisiana, indicated wide variations in consumption, ranging from 56 gallons per capita per day in Vacherie to 137 gallons per capita per day in Shreveport.[11]

Of the 231 water utilities comprising the sample, in this study, 129 (56 percent) provided information with respect to the amount of water consumed by customers in 1971. Fifty-five of those in the sample used a system of flat rates and had no record of water consumption. It should be pointed out that systems using metered rates should not only be able to provide an estimate of water consumption, but also the amount of water supplied. The amount supplied is greater than actual consumption by the amount of water lost during the process of transmission and distribution. Generally, average water loss is about 12 percent of actual consumption.

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[10] Gulf South Research Institute, Present Municipal Water Use in Louisiana, op. cit., p. 5.

[11] Information supplied by the American Water Works Association, (New York: October 15, 1973).

In Table 12, it can be seen that water consumption ranged from a low of 50 gallons per capita per day to a high of 150 in this study. Within this range, consumers supplied by FHA water utilities utilized between 50-100 gallons per capita per day, while consumers supplied by municipal water utilities were predominantly in the 101-150 gallons per capita per day category. This difference is accounted for by the fact that FHA water utilities serve primarily rural areas, whereas municipal water utilities generally serve urban areas where per capita consumption would be expectedly higher.

Table 12. Water Consumption Per Capita Per Day and Ownership of Water Utilities in Louisiana, 1971

Gallons per capita per day	Type of ownership			
	Municipal	Private	FHA	Total
	- - - - - Number of water utilities - - - - -			
50 - 75	5	7	30	42
76 - 100	9	9	21	39
101 - 125	12	12	10	34
125 - 150	10	2	2	14
Total	36	30	63	129

<u>Elasticity of Residential Water Demand</u>: A discussion of the demand for residential water must eventually consider both price and income elasticity of demand. These are measures of the percentage changes in the quantity of water taken with respect to percentage changes in prices and percentage changes in consumers income respectively. How changes in price affect water consumption are relevant considerations in determining

the pricing policy of water utilities. With an elastic demand for water, total revenue will decrease as a result of an increase in price, and vice-versa. With an inelastic demand, total revenue will increase with an increase in water rates, whereas with a unit elasticity, any change in rates will leave total revenue unaffected.

Elasticity, although rather difficult to measure at a point in time, has been estimated in terms of residential water use. Charles Howe found that the demand for domestic water is price inelastic and the demand for sprinkling water is relatively price elastic,[12] i. e., water consumers are more responsive to price changes for water used for sprinkling. Howe and Linaweaver, later found that the price elasticity of total residential demand was 0.04, as a weighted average of domestic and sprinkling elasticities.[13]

Afifi acknowledges the low sensitivity of water demand to water prices. He found in his study of municipal water pricing in Illinois that a change in the price of water "was irrelevant or as having no major effect on the growth of the water utility."[14] The major influential factors were population served and the level of economic activity. Both of these factors generate more customers, the latter associated primarily with large users. He further claimed that increased "water demand (and revenues) depends more on the increase in consumer count rather than the

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[12]Charles Howe, "Water Pricing in Residential Area," Journal of American Water Works Association, Volume 60, No. 5, May 1965, pp. 497-501.

[13]Charles Howe and Linaweaver, op. cit., pp. 497-501.

[14]H. H. H. Afifi, op. cit., p. 3.

increase in consumption per customer.[15] Therefore, as price increases, domestic water consumption may not be altered significantly to offset such increases in price, i. e., the percentage change in price may be greater than the percentage change in water demanded. It is this relative change in price and quantity that characterize the demand for domestic water as price inelastic.

The price charged for domestic water, primarily by private water utilities, must by law at least provide for a fair return on investment if the future growth of the water utility is to be assured to meet increased demands on the part of water customers.[16] Private water utilities will not supply water unless they can survive economically. Afifi's claim, therefore, is not pertinent to private water utilities, but probably to municipal water utilities to which his study was dedicated. Municipal water utilities are less dedicated to recover costs of production since any financial deficits can be restored from the municipal budget.

<u>Variations in Water Pricing</u>: Water rates depend on the demand for water, the nature of ownership of water utilities and differences in the costs of obtaining water supplies in different geographic regions. In Table 13, the average price charged for 10,000 gallons of water ranged from a low of $6.95 per month in southeast Louisiana to an average high of $10.11 in north central Louisiana.

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[15] <u>Ibid</u>.

[16] Leonard Weiss, <u>op</u>. <u>cit</u>., p. 236.

Based on type of ownership, the average monthly charge for 10,000 gallons of water supplied by FHA utilities, is $1.84 higher than the average charge for all water utilities surveyed. As expected, the charge of $6.74 by municipally owned utilities, is the lowest at $1.50 less than the average charge for utilities in the sample.

Different prices are acceptable provided they are consistent with variations in the average cost of production. In other words, if a water utility is to maintain financial solvency, the total revenue generated from its rates should at least be sufficient to cover the relevant costs incurred in the production of a given water service.

Table 13. Computed Average Monthly Rates Charged by Water Utilities for 10,000 Gallons of Water, Louisiana, 1971 1/

Water resource planning area	Municipal	Private	FHA	Average regional charge
	--------Dollars per 10,000 gallons per month--------			
Northwest	8.05	7.47	10.11	8.54
North Central	7.27	12.12	10.94	10.11
Northeast	6.76	7.53	10.73	8.34
Southwest	6.80	6.15	10.30	7.75
South Central	6.28	9.44	9.54	8.42
Southeast	5.28	4.70	10.87	6.95
Louisiana	6.74	7.90	10.08	8.24

1/ Based on a sample of 231 water utilities

The price differences in Louisiana becomes more obvious when the charge per 5,000 gallons (Table 14) is compared to the charge for an average family's consumption of 10,000 gallons per month (Table 13). The average charge in the state for 5,000 gallons of water is $5.61, and the average charge for 10,000 gallons is $8.24 or an increase of 47 percent for twice the volume of water. If a single fixed price per 1,000 gallons were charged by water utilities one would expect the charge per 10,000 gallons to be 100 percent greater than that for 5,000 gallons. This, however, is not the case since rate schedules include declining block rates and are characterized generally by second-degree price discrimination.

Table 14. Average Charge for 5,000 Gallons of Water by Water Utilities in Louisiana, 1971 1/

Water resource planning area	Ownership of water utilities			Average regional charge
	Municipal	Private	FHA	
	Dollars			
Northwest	4.13	6.88	7.72	6.24
North Central	4.26	5.08	7.86	5.73
Northeast	4.86	4.10	6.50	5.15
Southwest	5.36	3.76	6.63	5.25
South Central	3.91	5.46	7.55	5.64
Southeast	4.38	4.48	8.03	5.63
Louisiana	4.48	4.96	7.38	5.61

1/ Based on a sample of 231 water utilities

Supply Characteristics

Water for residential use must be of a higher quality than water supplied for agricultural or industrial use. Quality becomes of extreme importance where water supplies are becoming relatively scarce and the demands by agriculture and industry compete with residential demands. Since health and well-being are likely to be affected under these circumstances, government intervention becomes necessary in assuring an adequate quantity of water at reasonable prices and an appropriate standard of water quality.

Because government regulated rates are usually at relatively low levels, the price of water does not effectively ration supplies.[17] Instead, water utilities are urged to meet these "unrestricted" demands, which in turn calls for efficient management of supply costs if the water utility is to survive economically. This is somewhat analogous to price control imposed by government in which all firms must adjust their costs and efficiency in order to survive, irrespective of consumer's demands for the commodity produced.

Faced with regulated rates, providing water supplies becomes more complex. Water utilities are still expected to have a supply capacity, not only to meet the daily average consumer demand, but also the variation in seasonal and peak demands. Moreover, when the initial capacity is planned, account must be taken of the demand likely to

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[17] Robert K. Davis and Steve H. Hanke, _op_. _cit_., p. 40.

result from community growth in succeeding years. This situation makes water demand an estimated and uncertain element in water utility practice and generally results in an immediate excess supply capacity which can be achieved only at a level of capital investment that generates a higher cost of production. These capital costs include the construction of a water plant, a water treatment facility, equipment, pumps, storage tanks, and transmission and distribution lines.

Sources of Supply: Water supplies come from two sources; ground water and surface water. Water obtained from underground sources is generally more costly than water obtained from surface sources since the former requires a higher level of investment, particularly in the establishment and maintenance of water wells. The degree of difference in costs, however, is contingent upon the depth of the ground water table and the quality of water obtained.

Surface water is regarded as having a lower quality and therefore involves a higher cost for treatment before it is distributed for final consumption. However, even with the cost of water treatment considered, water obtained from ground water sources are generally more costly than surface water.

In Louisiana, ground water sources are more predominant with 95.6 percent of the utilities reporting water supplies obtained from these sources (Table 15). Apart from the cost aspects, this predominance is accounted for by the apparent abundance of ground water which requires less treatment than surface water. Once the well is established, the major component of the cost of production is related primarily to energy needed to extract the water.

Table 15. Sources of Water Supply in Louisiana, 1971

Source	Percentage supplied				Sample total	Adjusted total	Adjusted percent
	100	80-99	40-79	10-39			
	----Number of utilities----						
Well	220	1	-	-	221	303	95.6
Lake	2	-	1	-	3	4	1.3
River	2	-	-	1	3	4	1.3
Bayou	2	-	-	-	2	3	0.9
Purchased	2	-	-	-	2	3	0.9
Total	228	1	1	1	231	317	100.0

The dependence on ground water supplies, however, is becoming a critical problem in areas of the state where the water table has already reached a critically low level due to excessive pumping for use by agriculture and industry.[18] As a consequence, water utilities are required to drill wells to greater depths with the likelihood of encountering water of a lower quality. Surface water may therefore be a growing source of supply as demands increase. Already the New Orleans Water and Sewerage Board, the largest water utility in the state depends upon surface water as a source of supply. There is an abundance of surface water in Louisiana in rivers, lakes, and bayous. However, the purity of the water

[18] A. H. Harder, Chabot Kilburn, H. M. Whitman, and S. M. Rogers, "Effects of Ground Water Withdrawals on Water Levels, and Salt Water Encroachment in Southwestern Louisiana," Water Resources Bulletin No. 10, Department of Conservation, Louisiana Geological Survey and Louisiana Department of Public Works, 1967, p. 1.

is often questionable and the availability favors the riparian land owner; whereas wells can be drilled almost anywhere, at lower costs of transmission and distribution.

Very few water utilities purchase water from an outside agency. Table 15 shows that only three (0.9 percent) of the water utilities purchase water for resale to their customers. Apparently, the small populations served by these water utilities do not justify the costs involved in developing a separate source of supply.

Distribution of Water: An efficient and satisfactory distribution of water for residential consumption constitutes an important function of a water utility. Systems of distribution must be designed to meet current and anticipated demands. The distribution system, however, is not only contingent upon the availability of supply, but also on population distribution and the topography of the area served. Populations that are scattered and located at relatively high altitudes will require longer distribution lines and greater pumping capacity on the part of the utility. For this reason, it is more economical for water utilities to serve densely populated areas located on relatively flat land areas.

From an economic standpoint, an important cost factor is the population served per mile of distribution line. In Table 16, 40.7 percent of the municipal water utilities served a scattered population of between 200 or less per mile of distribution line, whereas 91.4 percent of the private water utilities, and 96.8 of the FHA water utilities, served similar populations.

Table 16. Population Served Per Mile of Distribution Line for Water Utilities in Louisiana, 1971

Population served per mile	Type of ownership: Municipal	Private	FHA
	- - - - - - - - Percent - - - - - - - -		
50 or less	13.0	20.6	23.8
51 - 100	11.1	40.6	47.6
101 - 200	16.6	30.2	25.4
201 - 300	20.4	3.8	1.6
301 - 400	22.2	2.2	1.6
401 - 500	9.3	2.6	0.0
Above 500	7.4	0.0	0.0
Total	100.0	100.0	100.0

A significant implication of the population served per mile of distribution line is the relatively higher level of investment in distribution lines by private and FHA water utilities. Investment in distribution lines constitute the major component of total investment in these two classes of water utilities. Actually, in some water utilities, investment in distribution lines accounted for as much as 50 percent of their total capital investment. The average investment expenditure in distribution lines by FHA utilities is estimated at 48 percent of total expenditure whereas for municipal water utilities it was 43 percent of total expenditure. This would be expected since FHA water utilities serve rural areas.

Water Production and Water Losses: For an effective water system, production must be consistent and adequate amounts must be stored to meet demands that are likely to develop. Moreover, the performance of the distribution system, is generally evaluated by the minimization of water losses during the process of distribution. Weak pipelines unable to withstand necessary water pressures result in considerable losses of water, the costs of which are borne by the water utility, and ultimately by the consumer. Water losses are a serious consideration where water utilities do not have a dual system of metering, one at the source to measure production and others at points of consumption. Large water losses, not only through the distribution system, but at the water plant as well, require a high level of production and great storage capacity. Therefore, water losses generate higher costs of water service and with regulated water rates facing all water utilities such water losses can aggravate the economic condition of financially depressed water utilities.

From Table 17 it can be seen that, of 231 utilities which responded to the survey, only 100 reported the amount of water produced for residential use. The failure to report the volume supplied was due to the fact that many water utilities, especially those using flat rates (55), have no records of water production. Moreover, many that have records do not differentiate by type of use.

The high cost of acquiring master meters is undoubtedly reflected in the fact that 100 percent of the municipal utilities reported water production, whereas, only 38 percent of the private water utilities indicated amounts of water produced. The greater response of municipal

Table 17. Volume of Residential Water Produced by Water Utilities in Louisiana, 1971

Volume	Types of ownership			Total
	Municipal	Private	FHA	
Gallons	- - Number of water utilities - - - - - -			
10,000 - 1,000,000	4	3	-	7
1,000,001 - 5,000,000	4	4	2	10
5,000,001 - 10,000,000	8	9	2	19
10,000,001 - 20,000,000	10	16	-	26
20,000,001 - 50,000,000	12	8	-	20
50,000,001 - 100,000,000	6	2	-	8
100,000,001 - 500,000,000	6	-	-	6
Above 500,000,000	4	-	-	4
Total	54	42	4	100
Water Resource - Planning Area				
Southeast	8	3	-	11
South Central	5	9	-	14
Southwest	13	8	-	21
Northeast	7	5	2	14
North Central	11	6	2	19
Northwest	10	11	-	21
Total	54	42	4	100

water utilities is a reflection of their ability to finance costly master meters, since these utilities are not solely dependent for their economic survival from revenues generated from the sale of water, but also from the sale of public bonds or financial subsidies from the municipal government. Although FHA water utilities can obtain funds from the FHA to establish a water system, it will be noted that only 6 percent (4 water utilities) of all FHA water utilities have production meters. The absence of master meters among these water utilities, according to the FHA, is that they are too costly and their use is not justified for the relatively small populations served in rural areas by these water utilities. Already the charges for residential water provided by the FHA water utilities are the highest among the water utilities surveyed. Acquisition of production meters would serve to increase further these charges. Thus, FHA water utilities rely mainly on a system of meters established to record customer's usage.

Recording the quantity of water produced and consumed does not in itself eliminate losses of water for, even with the most accurate recording system, a water loss of about 12 percent is generally expected. This percentage loss occurs in the transmission and distribution system. Leaks are generally reported by customers. New technological developments are permitting the use of radar equipment to detect weak or ruptured pipelines. This technique is already in use by water utilities in some large cities such as San Juan, Puerto Rico.

As reflected by this survey, water losses ranged from a minimum of 15 percent to a maximum 25 percent of water production, with the greater proportion of water utilities providing an estimate of 20 percent. The municipal water utilities reported most losses. This loss of water, although inevitable, is important from the standpoint of the costs and pricing of water. Normally, the costs of water losses are reflected in water rates to consumers who do not actually consume such water.

Investment by Water Utilities: Investment expenditures by water utilities depend on the anticipated demand for water, the size of population served, and the source and quality of water available. Apart from these three factors, however, it should be pointed out that decisions to invest in a water utility are governed to a large extent by the social and political obligations associated with the provision of water for human needs. As an indispensable commodity for health and survival, local government is normally expected to assure adequate water services.

The level of investment by water utilities is at most times based on the maximum demand expected to be imposed on the water system. As a result it is not unusual to find in water utility practice that, due to the excess capacity required by maximum demands, the level of investment is well above the level required to meed the "average" demand of water customers. Over-investment by water utilities is further based on the fact that investment in water utilities occurs in "notches" or discrete blocks, not only to meet current water demand but also expected future demand.

Another factor which may stimulate over-investment by water utilities is the use of unmetered water rates by some utilities. Flat rates encourage careless use of water beyond the necessary amount required for consumption needs. This waste stems from the fact that consumers pay a fixed charge for a given time period regardless of the quantity of water consumed.

The level of investment as mentioned earlier depends upon, among other factors, the population served and somewhat related to this, the type of ownership of water utilities. Table 18 shows the total investment by 223 water utilities based upon these two factors. Normally, it is expected that as the population served increases, total investment in water utilities will increase likewise. For example, at a population range of 500 or less 68 water utilities, or 69 percent, incurred a total investment of $50,000 or less, whereas at a population range of 501-1,000, the same percentage of water utilities reported a total investment of above $50,000. At a population range of 1,001-3,000, 47 percent of the water utilities reported investment expenditures of above $100,000.

Based on ownership, the largest number (48) of the private water utilities reported a total investment of $25,000 or less. These, generally are water utilities serving small populations in Louisiana. On the other hand 45 (87 percent) of the 52 municipal water utilities reporting invested $100,000 or more, which testifies that most of these water utilities are serving larger and denser populations. The FHA water utilities, located in rural areas and serving small populations, reported investments above $25,000. Most were over $50,000.

A significant comparison among these three types of water utilities

Table 18. Number of Water Utilities by Population Served, Total Investment, and Ownership, Louisiana, 1971

Classification	Total investment $0-25,000	$25,001-50,000	$50,001-100,000	Above 100,000	Total utilities
	- Number of water utilities -				
Population served					
1 - 500	44	24	26	4	98
501 - 1,000	4	11	13	21	49
1,001 - 3,000	2	3	15	18	38
3,001 - 5,000	-	-	-	9	9
5,001 - 10,000	-	-	1	7	8
10,001 - 25,000	-	-	-	9	9
25,001 - 50,000	-	-	-	3	3
Above 50,000	-	-	-	9	9
Total	50	38	55	80	223
Ownership					
Municipal	2	-	5	45	52
Private	48	25	22	12	107
FHA	-	13	28	23	64
Total	50	38	55	80	223

is to examine the investment per capita. Table 19 shows that about 72 percent of the private water utilities in the sample had a per capita investment of $100 or less, whereas 95.5 percent of the FHA water utilities incurred a per capita investment ranging from $100 to $300. Although the municipal water utilities reported an average total investment of above $100,000, about 72 percent had a per capita investment of $200 or less.

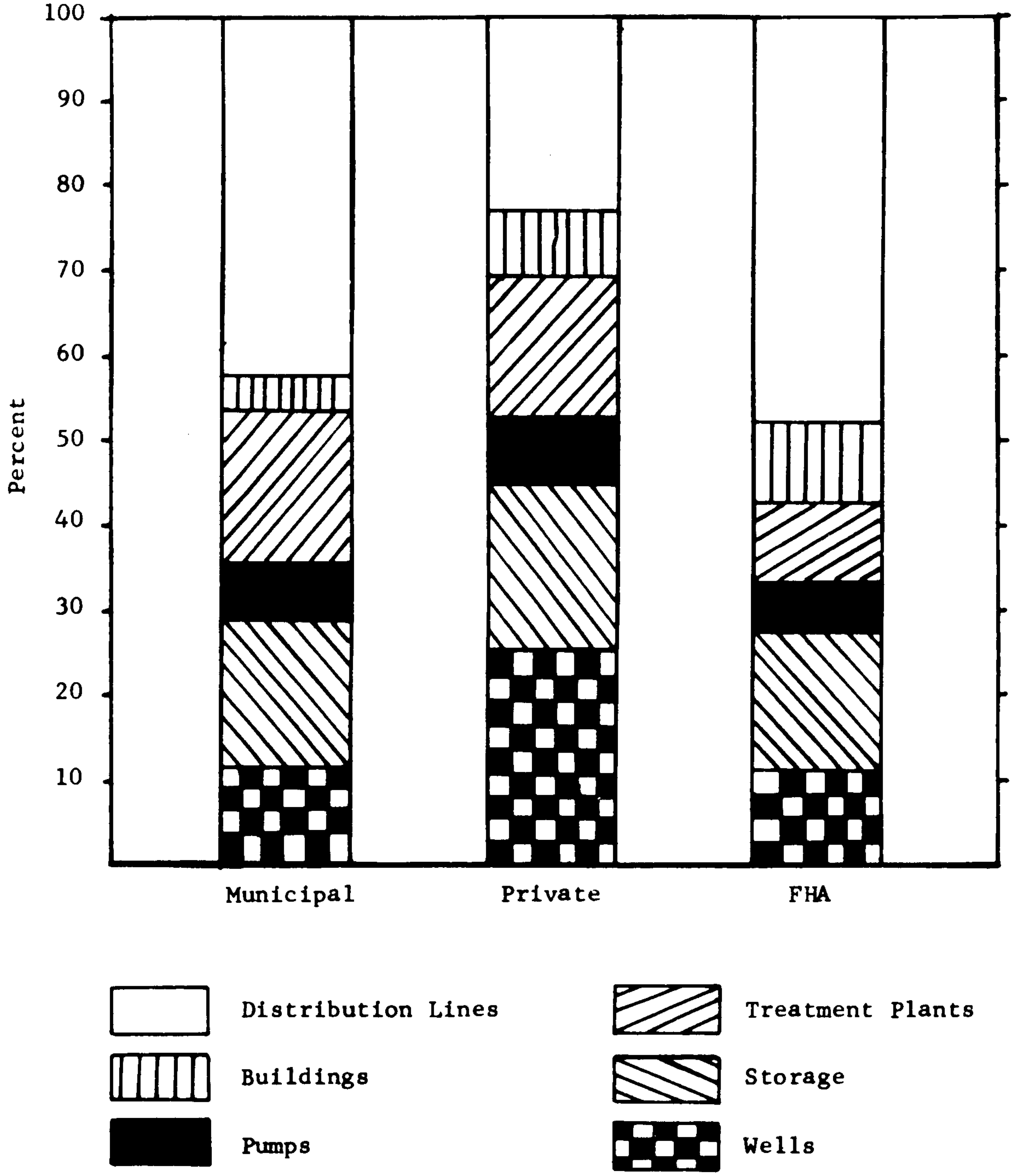
The total investment of water utilities for the purpose of this study included investment in wells, storage facilities, pumps, treatment plants, buildings, and distribution lines. Chart 2, presents a percentage distribution of these components of total investment among the three types of water utilities. The percentage distribution represents the mode, or most common value encountered in each class of water utility. Based on this chart, 48 percent of the investment

Table 19. Per Capita Investment by Water Utilities in Louisiana, 1971[1/]

Per capita investment	Type of ownership		
	Municipal	Private	FHA
(Dollars)	Percent		
0 - 100	37.0	71.7	3.0
101 - 200	34.8	18.5	55.2
201 - 300	17.4	3.3	40.3
301 - 400	6.5	4.3	1.5
401 - 500	4.3	2.2	0.0
Total	100.0	100.0	100.0

1/ Based on a sample of 231 water utilities

Chart 2. Relative Distribution of Total Investment Expenditures by Water Utilities in Louisiana, 1971.



expenditures for cooperative water utilities was for distribution lines, whereas it was 43 percent and 22 percent for municipal and private water utilities, respectively. Investment in distribution lines constitute the largest component of total investment by municipal and FHA water utilities; investment in wells by private water utilities exceeds investment in distribution lines by only 2 percent. The greater investment in wells is evidenced by the location of private water utilities, most of which are in the south central region of Louisiana.

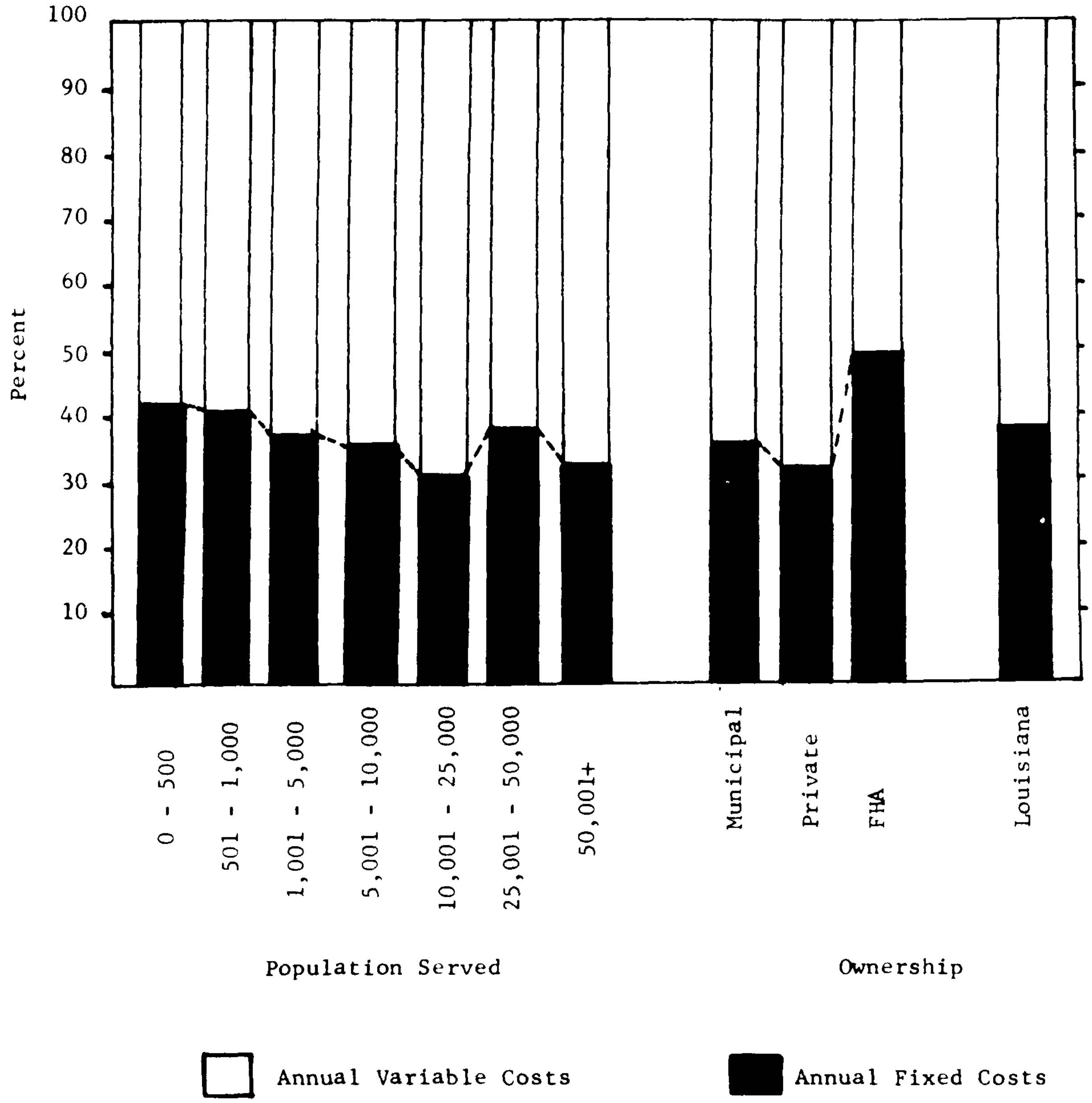
Cost of Residential Water Supplies: The costs associated with provision of water services is the most fundamental element in arriving at the rate structure and rate schedules of water utilities since it is generally accepted that total revenue should cover total costs, including a fair return on investment. These costs are generally based on the economic characteristics of supply for water. However, due to the social value of water to a community, and the regulation of water rates, water utilities must strive for efficiency of operations if economic survival is to be assured. This efficiency is reflected in the average cost of production and concomitantly with the realization of a net income.

To facilitate a cost analysis in this study, total annual operating costs (TOC) were subdivided into two components: (1) total annual variable costs (TVC), and (2) total annual fixed costs (TFC). Total annual variable costs are those costs which vary with the volume of output of the water utility and include costs incurred for maintenance and repairs, pumping, purification, transmission and distribution, customer accounting and collecting. Total annual fixed costs on the other hand do not vary with the operation of the water utility and include depreciation, charges for interest on loans, rents, insurance, and taxes.

In Chart 3, a comparison is made of the proportion of annual variable costs and annual fixed costs of the total annual cost of operating a water utility. Based on population served, it is shown that annual fixed costs constitute the highest percentage (43 percent) of total annual costs at a population range of 500 or less whereas it is lowest (31 percent) at a population range of 10,000-25,000. Based on ownership of water utilities, annual fixed costs constitute the highest percentage (48) of total annual costs among the FHA water utilities whereas it is the lowest (32 percent) in private water utilities. It should be noted for all water utilities in Louisiana, annual fixed costs constitute 38 percent of total costs.

Economic theory suggests that costs are a function of output, price of resources, technological changes, size of plant and the number of sellers in a market. On the other hand revenues are a function of the price of a commodity, the price of substitutes and complements, income, and the number of buyers (population) in a given market. However, several studies have confirmed that although revenue is a function of population served the costs of operating a water

Chart 3. Percentage Distribution of Fixed and Variable Costs of Water Utilities in Louisiana, 1971.



utility is also a function of population served.[19] To examine this functional relationship for this study, regression analysis was used, with population served as the independent variable and total annual operating cost as the dependent variable. This was done for all water utilities reporting by size of population groups and by ownership of water utilities. The results are shown in Table 20.

Based on these results, 59 percent of the variation in total annual costs of 224 water utilities is due to the size of population served. This was significant at the .0001 level. The coefficient of regression (B-value) was positively sloped implying that as population served increased, the total costs of operation increased also, but the average total costs declined consistently. This explains that the fact that water utilities in Louisiana may be, generally, in a decreasing average cost stage of their operations.

The results of the regression analysis also confirm the importance of the ownership of water utilities with respect to their total annual costs and population served. Based on ownership of water utilities, the percentage variation in total annual cost accounted for by population served is relatively more significant than when the different groups of population are taken into account. For example, the

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[19] Arthur B. Daugherty and J. Dean Jansma, "Economies of Size Among Municipal Water Authorities in Pennsylvania," Southern Journal of Agricultural Economics, Vol. 5, No. 2, December 1973, pp. 1-5; Walter B. Hobgood, A Cost Analysis of Rural Water Systems in Louisiana, Unpublished Master's Thesis, Louisiana State University, May, 1974; National Water Commission, Water Policies for the Future: Final Report to the President and to the Congress of the United States, Washington, D. C.: U. S. Government Printing Office, 1973, p. 249.

Table 20. Regression of Total Annual Cost (TOC) on Population Served by Water Utilities in Louisiana, 1971 1/

	Linear model 2/	Intercept	B-value	"t" for H_0:B = 0	Significance level	R^2
All water utilities	TOC = f(POP)	8,060.99	8.34	15.88	.0001	0.5891
Population groups	f(POP)					
Less than 1,000	TOC = f(POP)	1,324.02	15.26	4.67	.0001	0.1469
1,000 - 10,000	TOC = f(POP)	6,881.25	12.21	4.31	.0001	0.3285
10,001 - 50,000	TOC = f(POP)	153,412.45	1.20	0.29	.7755	0.1239
Ownership						
Municipal	TOC = f(POP)	29,709.59	6.20	5.04	.0001	0.4848
Private	TOC = f(POP)	478.34	17.31	13.79	.0001	0.6962
FHA	TOC = f(POP)	422.80	15.86	24.48	.0001	0.8989

1/ Excludes water utilities serving populations above 50,000, since their inclusion resulted in a negative intercept.

2/ Quadratic or cubic models did not improve the analysis.

coefficient of determination (R^2) ranged from 0.1239 to 0.3285 by population size groups, whereas by ownership of water utilities, it ranged from 0.4848 among municipal water utilities to 0.8989 among FHA water utilities. All coefficients of determination, based on population or ownership of water utilities, were significant at the .0001 level of probability.

Based on ownership of water utilities the total annual operating costs can be expressed as follows:

<u>Ownership</u>	<u>Total Annual Operating Cost</u> (TOC)
Municipal	$TOC = \$29,709.59 + \$6.20\ X_1$
Private	$TOC = \$478.34 + \$17.31\ X_1$
FHA	$TOC = \$422.80 + \$15.86\ X_1$

Since the foregoing serves to illustrate that water utilities in the sample are characterized by decreasing average costs of operation, the analysis now turns to the examination of the average total cost (ATC) per capita of the water utilities surveyed. Based on population groups served, the lowest ATC \$10.60 was between the population range of 10,001-50,000 while the highest (\$26.30) ATC per capita was for populations of 100 or less (Table 21 and Figure 7). Based on ownership of water utilities the ATC per capita was lowest among the municipal water utilities and highest among the private water utilities. This is not surprising since municipal water utilities are generally located in urbanized areas serving larger and denser populations. The ATC per capita of these water utilities appears to have a direct relationship with their financial status for as shown later the largest percentage of water utilities which incurred financial losses in 1971 were privately owned utilities having relatively high average total costs of production.

Table 21. Average Cost Per Capita by Population Served and Ownership of Water Utilities in Louisiana, 1971 1/

Classification	Mean	Range
	-----------Dollars---------------	
Population served		
0 - 100	26.30	3.90 - 93.35
101 - 200	15.86	3.69 - 52.35
201 - 300	16.43	6.90 - 34.44
301 - 400	16.88	7.05 - 25.75
401 - 600	17.00	8.73 - 25.53
601 - 800	14.66	1.43 - 23.90
801 - 1,400	19.43	9.50 - 35.78
1,401 - 2,400	16.13	2.05 - 47.20
2,401 - 5,000	12.35	6.48 - 16.22
5,001 - 10,000	14.58	5.48 - 49.71
10,001 - 50,000	10.60	0.96 - 16.50
50,001 - 560,000	11.47	1.58 - 19.94
Ownership		
Municipal	13.37	0.96 - 34.45
Private	17.74	1.44 - 95.35
FHA	16.63	7.05 - 27.65

1/ Based on a sample of 231 water utilities

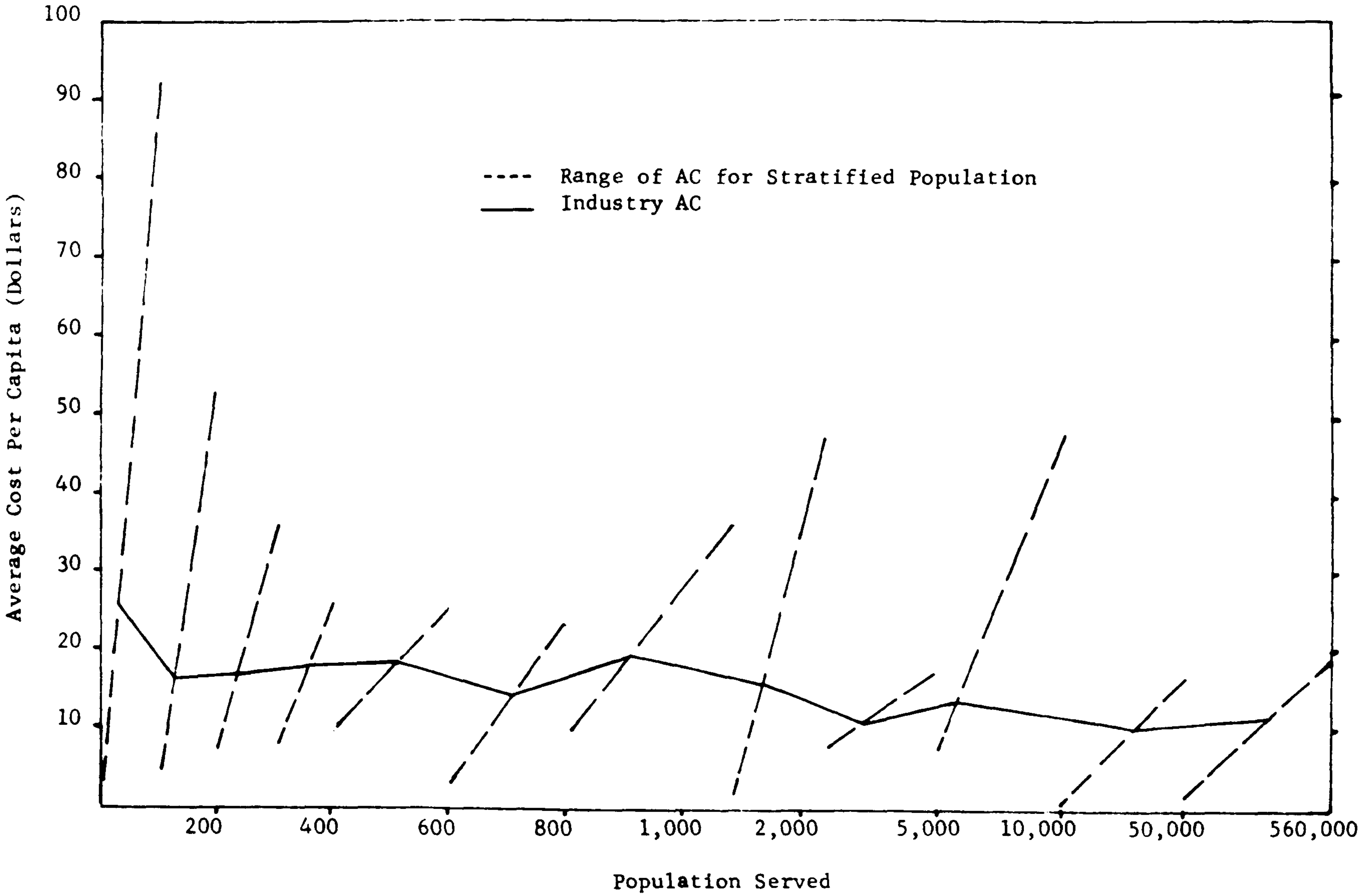

Figure 7. Average Cost Per Capita and Population Served by Water Utilities in Louisiana, 1971.

CHAPTER V

RESIDENTIAL WATER RATE SCHEDULES IN LOUISIANA

Functions of Water Rates

Before delving into an analysis of domestic water rate schedules in Louisiana, it is appropriate to review briefly the general functions of water rates as they relate to residential water consumption. Embodied in water rates is the concept of "reasonableness", a term which defies a uniform and clear-cut definition. Reasonable rates depend upon a diversity of factors which differ from place to place and also at different points in time. Some argue, they should be "what the traffic can bear", but this argument is remote to the realities of water pricing as the rates are normally well within the economic capability of the poorest members of society. Others argue that reasonable rates should be regarded as rates fairly in line with the prices of other goods and services supplied by non-utility type industries. Despite these two arguments, the cry for cheap and reasonable rates persists not only for water, but for other public utilities as well.

In view of the emphasis placed upon water rate pricing techniques, Bonbright notes that a water rate schedule should perform the four following functions: (1) the producer-motivation or capital attraction function, (2) the efficiency incentive function, (3) the demand control or consumer rationing function, and (4) the income distributive function.[1]

The producer-motivation or capital attraction function implies that a water rate schedule should be designed to generate an amount of revenue sufficient to cover all costs plus a return on investment. This return should be an amount sufficient to stimulate management to continue to provide water service, and also to serve as a reward to new capital investment as it becomes necessary from time to time for expansion of the water utility.

With respect to the efficiency-incentive function, it is as accepted goal which both public and private enterprises strive to attain since the degree of efficiency affects the rate of return. Too often the regulation of water utility rates determine the level of return, not based on efficiency, but rather by judgment of a governmental agency. Actually, this method of rate determination is often criticized when considering rate revisions because emphasis is placed on the revenue requirements of the water utility based generally on increasing costs. Very rarely do regulatory bodies raise questions as to the operation of the water utility in terms of efficiency.

The demand control or consumer rationing function is generally considered as one of the most important functions of water utility

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[1]James C. Bonbright, <u>Principles of Public Utility Rates</u>, (New York: Columbia University Press), 1961, p. 49.

rates. Here water rates are designed not to induce production, but instead to temper or influence consumer demand. The efficient performance of this function enables every potential consumer to receive whatever type of service the water utility undertakes to supply and in whatever amount he is willing to buy at the scheduled rates. Thus, water utility rates may be designed to avoid the necessity of direct rationing by making the consumer, in effect, ration himself. It is believed, however, that attempts at water rationing through price is minimal due to the relatively low rates associated with the use of water.

The fourth rate-making function relates to the ability to pay by customers and has as its objective the transfer of a desirable amount of purchasing power from buyer to seller, or from consumer to producer. This practice is common where water utilities provide supplies of water free of charge or at a nominal price to certain institutions such as churches and schools. Apart from this however, the current pricing practices favor the large volume users as they are charged relatively cheaper rates than the small consumers, as indicated by the declining block rates common among 85 percent of the water utilities in the United States.[2]

Types of Water Utility Rates

The regulatory element inherent in water utility rates is a major impediment in the fulfillment of the four functions outlined above.

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[2] "Modern Water Rates," The American City Magazine, (New York: Volume 70, No. 7), June 1955, p. 110.

This regulation is applicable to all classes of rates employed by water utilities. Generally, these classes are: (1) unmetered rates, (2) metered rates, and (3) special charges.

Unmetered Rates

Normally referred to as "flat rates", unmetered rates relate to a fixed charge for water services during a given time period, irrespective of the quantity of water consumed. In early water utility practice in the United States, flat rates were common and charges were based on such factors as number of rooms, number of fixtures, or other physical features of the customer's premises.[3] However, with the increased cost of supplying water, metered rates, which are the most prevalent method now in use, were implemented with the primary aim of rationing on an equitable cost basis and, at the same time, maintaining an adequate accounting of water losses throughout the distribution system.

Flat rates generally lead to excessive consumption while metered rates tend to encourage caution in the use of water.[4] Wasteful consumption promotes over-investment and, where accessibility to funds for investment is relatively easy as in publicly-owned water utilities,

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[3]Water Rates Manual, _op_. _cit_., p. 2.

Geoffrey Shibbs and Arthur Langolis, "Water Supply of Nassau, Bahamas," _Journal of American Water Works Association_, Volume 46, No. 3, March 1954, pp. 365-370, and Ralph Porges, "Factors Affecting Per Capita Water Consumption," _Water and Sewage Works_, Volume 42, No. 5, May 1957, pp. 199-204.

the fulfillment of such demands may pose no problem. However, where funds are limited, as in the case of privately-owned water utilities, a financial strain may be imposed and thereby adversely affect the economic health of the utility. This becomes a critical consideration to water utilities whose rates are regulated and characteristically inflexible.

Flat rates are also criticized on the basis of lacking an equitable method of allocating water costs according to the volume of water consumed by each class of customers. Such costs are distributed among the classes of water users regardless of their actual use or of the demand they impose on the water system. Where the utility serves one customer class, say residential customers, equitable costs distribution as reflected by charging a fixed flat rate to all customers, can be easily accomplished. However, when water is supplied to different classes of customers such as residential, industrial, and commercial users, and the same rate is accorded to all classes, inequitable distribution of costs will result, since the latter groups of customers generally demand a greater capacity of the water utility in comparison to residential customers.

Flat rates are acceptable for use only when some degree of uniformity prevails and it is possible to estimate the amount of use by each customer class with reasonable accuracy. Apart from this, the implementation of a fixed flat rate assumes that consumers are a homogeneous group with regard to their usage behavior. Where there are wide divergences in the quantity of water used among customer classes, some groups gain at the expense of others and consequently flat rates become inappropriate as a pricing policy in water utility practice, from an equity standpoint.

Some water utilities continue to use flat rates because of ease of administration. Also, small water utilities cannot afford the high cost of metering in their initial stages of operation. Apart from this, the continued use of flat rates is more readily accepted by the average customer since the reading of meters and computation of the monthly water bills are often suspect under a schedule of metered rates.

In Louisiana, the survey indicates that 24 percent of the water utilities still use flat rates and 5.6 percent have a combination of both flat and metered rates (Table 22). The majority, 70.6 percent use metered rates. A 1954 report on United States water utilities estimated that unmetered rates account for five to 10 percent of all water services.[5]

Table 22. Type of Water Rates Used by Water Utilities in Louisiana, 1971 1/

Rates	Number of utilities	Percent
Flat or unmetered rates	55	23.8
Metered rates	163	70.6
Flat and metered rates	13	5.6
Total	231	100.0

1/ Based on a sample of 231 water utilities.

[5] "Modern Water Rates," op. cit., p. 10.

Table 23 shows the population served and the nature of ownership for water utilities having flat rates in Louisiana. It will be observed that 69 percent of the utilities having flat rates served a population of 300 or less, an indication of the relatively small markets served by these water utilities. Surprisingly, about 15 percent serve populations between 1,001-5,000, which for Louisiana can be considered fairly large water systems. About 85.5 percent of the water utilities using flat rates are privately-owned, while only 14.5 percent are municipally-owned. As subsequently, shown, of the water utilities which use flat rates, 87.2 percent realized a net loss from their operations in 1971.

Table 23. Population Served and Nature of Ownership of Water Utilities Using Flat Rates, Louisiana, 1971 1/

Population served	Number of utilities	Percent
1 - 100	28	50.8
101 - 300	10	18.2
301 - 500	5	9.1
501 - 1,000	4	7.3
1,001 - 5,000	8	14.6
Total	55	100.0
Ownership		
Public	8	14.5
Private	47	85.5
FHA	--	--
Total	55	100.0

1/ Based on a sample of 231 water utilities.

Although serving small rural populations, the FHA water utilities in Louisiana do not use flat rates. This may be explained by the fact that these utilities are regulated and financed by the Farmers Home Administration and its an implied policy of the FHA that approval of loans is contingent upon repayment capacity; so a system of metered rates although initially more costly, will encourage customers to ration their consumption and also reduce water losses.

Flat rates, as reflected by the sample of water utilities, range from a minimum of $1.50 to a maximum of $7.50 per month (Table 24), with about 86 percent of the rates ranging between $2.00 - $6.00 per month.

Table 24. Flat Rates Imposed by Water Utilities in Louisiana, 1971 1/

Flat rate	Number of utilities	Percent
(Dollars per month)		
1.00 - 1.99	4	7.3
2.00 - 2.99	15	27.3
3.00 - 3.99	10	18.2
4.00 - 4.99	11	20.0
5.00 - 5.99	11	20.0
6.00 - 6.99	2	3.6
7.00 - 7.99	2	3.6
Total	55	100.0

1/ Based on a sample of 231 water utilities.

Flat rates may be standardized at one rate for all users, or, if variable, based on customer class or the physical features of water use. In the customer class, different fixed charges are imposed depending on whether the consumer is residential, commercial, industrial, or agricultural. On the other hand, the use category bases the rate upon physical fixtures such as the number of faucets and bathrooms in a home. Based on the survey one water utility reported that flat charge was based on the number of taps and the number of cows on the farm.

With meterless pricing, water losses from broken pipes, etc. cannot be quantified, a situation which can affect cost aspects adversely. Normally, the acceptable average loss of water by a water utility is estimated at about 12 percent of the total annual water production. Meters to gauge production at the pumping stations are being introduced more readily with the recent development of less expensive meters.

All water utilities reporting the use of flat rates, obtained their supplies from wells. Twenty of these utilities were located in the South Central region, 11 in the Southwest, 9 in Northeast, 7 in the Northwest, and 4 each in the Southeast and Northeast regions of Louisiana. The relatively large number of water utilities using flat rates in the South Central and Southwest regions is a serious consderation relating to water use, since these two regions are already confronted with water scarcity.

Recently, consumers voiced complaints against two water utilities in the South Central region for providing poor water quality and erratic pressures in water supply.[6] These two water utilities responded to the low quality charge by "having to push deeper and deeper into underground sands" in order to locate additional water supplies.[7] Moreover, they indicated that to improve the service a 22.5 percent increase in water rates would be necessary. This increase was granted only after improvement of service as requested by the Louisiana Public Service Commission.

It may be pertinent at this point, to examine the extent to which flat rates permit the attainment of the four stated pricing functions. Flat rates cannot achieve the efficiency, consumer rationing, and income redistribution functions because flat rates are non-differentiating. Moreover, variable flat rates, based on customer classes or estimated water use, may still not allow for the satisfactory fulfillment of these three objectives.

The function relating to capital attraction needs special consideration in that flat rates may or may not generate a level of income to provide a fair return to the utility. Such rates are fixed and change slowly, while the volumes of water consumption will vary considerably, thus, adding uncertainty to the rate of return to the water utility. This element of uncertainty makes capital investment risky and may fail to attract new capital. Even when capital funds

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[6] Morning Advocate, (Baton Rouge, Louisiana), September 22, October 3, October 7, and November 8, 1973.

[7] Ibid.

are available, they can be only obtained at a higher cost. With all the inherent deficiencies in a system of flat rates, it is not surprising then to note that, of the 55 water utilities reporting flat rates, only 12.8 percent realized a net income in 1971.

Metered Water Rates

To overcome the deficiencies which characterize flat rate pricing, most water utilities have turned to metered rates. Under such a system of rates: (1) means are provided for the establishment of an equitable rate structure, (2) consumers pay in proportion to the amount of water used, (3) waste is reduced, resulting in financial savings to all, (4) loads on treatment plants, pumping, etc. are minimized; and (5) water losses are easily detected and minimized.[8]

Despite the arguments favoring the use of metered rates, certain objections have been voiced against such a system. These include: (1) meters cost money to buy, install, maintain, and read, (2) pressure losses through meters are appreciable and result in added pumping costs; and (3) consumers resent a standby charge when water meters show no water used.[9] These criticisms have some validity, specifically where water supplies are plentiful and easy to deliver. However, where

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[8] Harold E. Babbet, James J. Doland, and John L. Cleasby, Water Supply, Sixth Edition, (New York: McGraw Hill Book Company), 1959, p. 17.

[9] Ibid., p. 17.

supplies are scarce or costly to deliver, these considerations are considerably weakened and there is a strong justification for the use of meters and metered rates.

Of 231 water utilities reported in the survey, 163 (70.6 percent) have metered water rate schedules and 13 (5.6 percent) have a combination of both flat and metered water rates (Table 25). The number of water utilities using metered rates outnumber those using flat rates by a ratio of about 3:1.

The type of rate system used by water utilities reporting in the survey, appears to exhibit a direct relationship with population served. For example, flat rates were more prevalent at a population level of 500 or less, whereas at a population level above 10,000, no water utilities reported the use of flat rates. However, it should be noted that 28.6 percent of the water utilities serving a population ranging between 10,001-15,000 used a combination of both flat and metered rates. This population range appears to be significant since the decision to change from a system of flat rates to metered rates is contingent upon its costs of implementation. Water utilities having both systems of water rates can be interpreted as in the process of changing from one system to the other, since the population they serve apparently justifies the change.

On the basis of ownership, the use of flat rates are most common among private water utilities and totally absent among the FHA water utilities. Although a larger percentage (74.1) of municipal water utilities use metered rates, it is rather striking to note that

Table 25. Water Rate Systems, Population Served, and Type of Ownership of Water Utilities in Louisiana, 1971 1/

Population served	Flat rates		Metered rates		Flat and metered rates		Total
	Number	Percent	Number	Percent	Number	Percent	Number
1 - 500	43	41.7	60	58.3	0	0.0	103
501 - 1,000	4	7.4	42	77.8	8	14.8	54
1,001 - 3,000	5	18.5	22	81.5	0	0.0	27
3,001 - 5,000	1	8.3	11	91.7	0	0.0	12
5,001 - 10,000	2	20.0	6	60.0	2	20.0	10
10,001 - 15,000	0	0.0	5	71.4	2	28.6	7
15,001 - 25,000	0	0.0	4	100.0	0	0.0	4
25,001 - 50,000	0	0.0	6	85.7	1	14.3	7
Above 50,000	0	0.0	7	100.0	0	0.0	7
Total	55	23.8	163	70.6	13	5.6	231
Type of Ownership							
Municipal	8	14.8	40	74.1	6	11.1	54
Private	47	42.0	58	51.8	7	6.2	112
FHA	0	0.0	65	100.0	0	0.0	65
Total	55	23.8	163	70.6	13	5.6	231

1/ Based on a sample fo 231 water utilities.

all FHA water utilities had a system of metered rates although these utilities are located primarily in rural areas and serve relatively smaller populations than those served by either private or municipal water utilities.

Although a metered system for FHA utilities may not be economically justifiable in terms of population served, meters do provide for closer accounting of water consumption and minimization of water losses, both of which are reflected in the cost-revenue functions of the water utility. Rates can be set in accordance with costs in order to insure financial survival and to adequately manage the repayment of the FHA loan.

In Louisiana, the survey indicates that the most common schedule of metered water rates is based on the declining block system. This system, as mentioned previously, is used in 85 percent of the water utilities in the United States, and it is premised on the assumption that as the water utility increases its output, greater economies of scale are realized, with a resulting decrease in average cost, lower water prices, and concomitant increases in consumption. The benefits of lower prices, however, are not generally enjoyed by the residential consumers, but instead by the large volume consumers such as industries and commercial establishments. Therefore, the economic implications of declining block rates are two-fold: (1) they are discriminatory,[10] and (2) with the demand for residential water

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[10]Richard A. Bilas, Microeconomic Theory, Second Edition, (New York: McGraw Hill Book Company), 1971, p. 216.

being price inelastic, the relatively higher prices to residential customers generate an increased total revenue to the water utility.

The use of declining block rates by water utilities in the sample is shown in Table 26 with the different blocks and their respective charges per 1,000 gallons per month. Of the total in the sample, 163 water utilities had at least two blocks; 140 three blocks, 113 four blocks, and 61 a fifth block. The proportionally greater use of two blocks, is based on two facts. First, a greater percentage of the water utilities serve relatively small populations; that is, 68 percent serve a population of 1,000 or less. Additional blocks will be dependent on increases in population, degree of heterogeneity of the population, and per capita consumption.

Another explanation to the more frequent use of two blocks among the water utilities, is that about 96 percent of all surveyed do not provide water supplies to large volume users such as manufacturing industries which, is shown later, are primarily self-supplied throughout Louisiana. These industries not only use larger volumes of water, but also utilize water of a lower quality than would be acceptable for domestic consumption.

The larger number of municipal water utilities using the five block rates rests, as mentioned previously, with the fact that these utilities are located in large urban areas serving a more heterogeneous population having a higher per capita consumption of water. Of the 61 utilities having a fifth block, 18 were located in the Southwest WRPA, 15 in the Southeast WRPA, and 12 in the South Central WRPA,

Table 26. Distribution of Water Utilities by Block Rates for Residential Water Use in Louisiana, 1971 1/

Rates	First block	Second block	Third block	Fourth block	Fifth block
Dollars per (1,000 gallons per month)	- - - - - - - - - - - - -	Number of utilities	- - - - - - - - - - - - -		
0.10 - 0.29	--	3	5	14	20
0.30 - 0.39	--	7	18	27	11
0.40 - 0.49	--	18	28	10	6
0.50 - 0.59	--	37	19	26	7
0.60 - 0.69	--	16	20	12	9
0.70 - 0.79	--	10	13	15	1
0.80 - 0.89	--	16	26	1	7
0.90 - 0.99	37	26	3	1	--
1.00 and more	126	30	8	7	--
Total	163	163	140	113	61
Ownership					
Municipal	40	40	39	32	26
Private	58	58	36	30	20
FHA	65	65	65	51	15
Total	163	163	140	113	61

1/ Based on a sample of 231 water utilities.

i. e., 74 percent of water utilities with a fifth block are in the southern region which is more urbanized than the northern region of the State.

An important element in the use of declining block rates is the difference in prices charged among the different blocks. As the volume of water consumed increases, the price per unit decreases accordingly. From an economic standpoint, large volume users are subsidized by small volume users and, for this reason, declining block rates are considered discriminatory. This discrimination in price also depends upon the price elasticity of demand for each customer class and as shown earlier the demand for residential water is relatively inelastic in comparison to the demand for water by industrial or commercial users.[11] For this reason water utilities accord higher prices to domestic users and lower prices to commercial users, both prices serving to increase total revenues at current levels of utility development.

Table 27 shows the degree of price differences expressed as a ratio between the second block and the last block, by population served and ownership of water utilities as reflected by the survey. The price of the second block was used instead of the price of the first block to avoid exaggeration or distortion of the ratio which is likely to result because in many cases the minimum charge also constitutes the price of the first block. An interpretation of the ratio, say 2.0, implies that

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[11] Charles Howe, op. cit., pp. 497-501; and Charles Howe and F. P. Linaweaver, op. cit., pp. 13-32.

Table 27. Distribution of Water Utilities as to Price Ratio of the Second Block Rate to the Last Block Rate, by Population Served, and Ownership, Louisiana, 1971 1/

Classification	Ratio of second block to last block		
	1.0 - 1.9	2.0 - 2.9	3.0 and above
	- - - - - - Number of utilities - - - - - -		
Population served			
1 - 500	49	9	2
501 - 1,000	19	9	2
1,001 - 3,000	15	7	1
3,001 - 5,000	5	3	2
5,001 - 10,000	4	1	3
10,001 - 15,000	1	3	4
15,001 - 25,000	2	4	5
Above 25,000	-	7	6
Total	95	43	25
Ownership			
Municipal	17	11	12
Private	28	20	10
FHA	50	12	3
Total	95	43	25

1/ Based on a sample of 231 water utilities.

the price of the second block is twice as great as the price of the last block.

Of the 163 utilities reporting the use of declining block rates, 95 had a ratio ranging from 1.0 - 1.9. This means that the difference in rates between the second and last blocks for 95 water utilities (52 percent) varied from a negligible difference to slightly less than twice the price of the last block. The price of the second block was 2.0 to 2.9 times that of the last block in 43 (26 percent) of the water utilities. Among the remaining 25 water utilities the price of the last block was one-third or less of the price of the second block. A significant relationship among these 25 water utilities, is that 15 served a population of 10,000 or more, indicating that greater rate differentials are possible as the size of population increases. On the other hand, more than 50 percent (49 water utilities) of those reporting a ratio ranging between 1.0 - 1.9 served a population of 500 or less. It can be concluded from the examination of ratios, that the difference in rates among blocks depends upon, among other factors, the size of population served.

On the basis of ownership, FHA water utilities were more predominant in the ratios ranging from 1.0 - 1.9, private utilities were common between 2.0 - 2.9 and municipal in a ratio of three above. Rates charged for residential water of a given volume by municipal water utilities are generally lower than for private and FHA water utilities. Confirmation of this observation can be noted in Table 28 where the average monthly charge for 10,000 gallons of water is shown. The average monthly charge for 10,000 gallons of water supplied by municipal utilities in the sample was $6.74; for private water utilities it was $7.90, and for FHA $10.08. Besides the fact that municipal utilities are located in large urban areas one should take into consideration also that these utilities may receive supplementary revenues from the municipal government.

Table 28. Computed Average Monthly Rates Charged by Water Utilities for 10,000 Gallons of Water, Louisiana, 1971 1/

Water resource planning area	Municipal	Private	FHA
	- - Dollars per 10,000 gallons per month - -		
Northwest	8.05	7.47	10.11
North Central	7.27	12.12	10.94
North East	6.76	7.53	10.73
South West	6.80	6.15	10.30
South Central	6.28	9.44	9.54
South East	5.28	4.70	10.87
Louisiana	6.74	7.90	10.08

1/ Based on a sample of 231 water utilities.

The Minimum Charge

Water utilities having a system of metered rates, generally impose a minimum monthly charge for a given quantity of water, whether this quantity is consumed or not. This charge insures the generation of a stable amount of revenue necessary to cover at least the fixed costs of the water utility. Baxter states, that the minimum charge should include "enough of the fixed charges of the utility to make sure that the system remains solvent under adverse economic conditions . . . (and) the charge should also be distributed in such a way that the various classes of customers pay their fair share."[12] Depending upon the revenue requirements of the water utility, the minimum charge may also include the recovery of certain customer-related costs such as meter reading, billing, and collection of payments.

A common practice among water utilities is to incorporate the minimum charge in the price of the first block in a system of declining block rates. When listed separately by utilities the minimum charge generally is considerably higher than the price of the first block.

Of the 163 water utilities having a system of metered rates based on the declining block method, 145 considered the minimum charge as the price charged for the first block of their rate schedules. Table 29 indicates, 22.7 percent of the reporting utilities charged a minimum of less than one dollar whereas over 50 percent charged $3.00 and above per month.

The use of meter size to determine the minimum charge is probably a more rational approach in the determination of the demand made on the capacity of the water system. Its use enables management to determine the capacity costs of a water system and thereby attempts to facilitate an equitable distribution of such costs in the rate structure of each customer class.

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[12] Samuel S. Baxter, "Principles of Rate Making for Publicly Owned Utilities," Journal of American Water Works Association, Volume 52, No. 10, 1960, p. 1237.

Table 29. Minimum Charges or Rates of First Block for Water Utilities in Louisiana, 1971 1/

Minimum charges or rates for first block per month	Number of utilities	Percentages
Less than $1.00	37	22.7
$1.00 - $1.99	10	6.1
$2.00 - $2.99	21	12.9
$3.00 - $3.99	17	10.4
$4.00 - $4.99	21	12.9
$5.00 - $5.99	34	20.8
$6.00 - $6.99	20	12.3
$7.00 and above	3	1.9
Total	163	100.0

1/ Based on a sample of 231 water utilities and includes the charge of 18 utilities with minimum based on five-eights inch meter size, since this was the most common type used.

Water demands by different classes of customers vary at different points in time. For example, a water utility serving residential customers is likely to experience peak demands in the early morning and late afternoon. In order to meet such demands the water utility must possess an excess capacity which would not be required if water use was constant. The realization of excess capacity entails higher fixed costs which, in terms of equity, should be reflected in a higher minimum charge to the customer class requiring this excess capacity. This can be achieved by the use of different meter sizes which accommodate peak water flows to the customer class in question.

Based on population served by water utilities, Table 30 shows the slight tendency for the minimum charge to decrease as population served increases. For example, 41.7 percent of the utilities serving a

Table 30. Percentage Distribution of Water Utilities by Monthly Minimum Charges, Population Served and Type of Ownership in Louisiana, 1971 1/

Classification	Dollars (minimum charge) 0 to 1.00	1.01 to 2.00	2.01 to 3.00	3.01 to 4.00	4.01 to 5.00	5.01 to 6.00	6.01 to 7.00	Number of Utilities
	- - - - - - - -			Percent of water utilities			- - - - - - - -	
Population served								
1 - 500	0	1.7	6.7	16.7	28.3	41.7	5.0	60
501 - 1,000	0	0	16.6	16.6	28.6	31.0	7.2	42
1,001 - 3,000	0	22.7	22.7	22.7	13.6	18.2	0	22
3,001 - 5,000	0	0	54.5	0	45.5	0	0	11
5,001 - 10,000	0	50.0	33.3	16.7	0	0	0	6
10,001 - 15,000	20.0	60.0	20.0	0	0	0	0	5
15,001 - 25,000	25.0	75.0	0	0	0	0	0	4
25,001 - 50,000	33.3	66.7	0	0	0	0	0	6
Above 50,000	57.1	28.6	14.3	0	0	0	0	7
Type of ownership								
Municipal	12.5	25.0	30.0	10.0	5.0	10.0	7.5	40
Private	0	17.2	24.1	20.7	29.3	6.9	1.8	58
FHA	0	0	0	10.8	27.7	53.8	7.7	65

1/ Based on a sample of 231 water utilities and includes utilities with minimum based on meter size.

population of 500 or less have a minimum charge of between \$5.01-\$6.00 whereas 57.1 percent of the utilities serving populations above 50,000 have a minimum charge of one dollar or less per month. The difference is accounted for by an impressive decline in the average fixed cost of production as population served increases, and since the minimum charge is designed to cover at least this cost, its level is accordingly lower.

Based on type of ownership, more than 65 percent of the municipal water utilities have a minimum charge of \$3.00 or less, whereas only 41 percent of the private water utilities had a similar minimum charge. On the other hand, 100 percent of the FHA water utilities charged more than \$3.00, with about 60 percent charging a minimum ranging between \$5.01-\$7.00. This relatively higher minimum charge by FHA water utilities results from the higher average fixed cost incurred specifically in their distribution systems designed to provide water to small and scattered populations in rural areas of Louisiana.

Although the foregoing analysis was based on the minimum charge, one may question its validity since the quantity of water allowed in the minimum is not the same for all water utilities. Therefore, a more meaningful comparison among water utilities, requires the calculation of the charge per thousand gallons of water allowed in the minimum as shown in Table 31. The data in the table verify previous conclusions but with a slight variation for the private and municipal water utilities, i. e., more than 65 percent of both private and municipal water utilities charge \$1.50 or less per 1,000 gallons whereas about 89 percent of the FHA utilities charge more than \$1.50.

Table 31. Distribution of Water Utilities by Minimum Charge Per 1,000 Gallons of Water, Louisiana, 1971 1/

Minimum charge	Municipal		Private		FHA	
per 1,000 gallons	Number	Percent	Number	Percent	Number	Percent
(Dollars)						
Less than 0.50	1	3.6	2	3.8	0	0
0.50 - 1.00	15	53.6	27	51.9	0	0
1.01 - 1.50	5	17.9	8	15.4	7	10.8
1.51 - 2.00	3	10.7	4	7.7	22	33.8
2.01 - 2.50	2	7.1	3	5.8	19	29.2
2.51 - 3.00	2	7.1	8	15.4	17	26.2
Total	28	100.0	52	100.0	65	100.0

1/ Based on a sample of 231 water utilities and excludes the 18 utilities that base the minimum on meter size.

Variations in the quantity of water provided in the minimum by population served and ownership of water utilities in Louisiana are presented in Table 32. The tendency is noted that as population served increases, a larger percentage of water utilities allow a larger quantity of water in the minimum. For example, at a level of population of 500 or less, more than 60 percent of the water utilities provide for a minimum of less than 4,000 gallons per month, whereas at a population of above 50,000, more than 60 percent of the water utilities permitted 4,000 gallons or more in the minimum. However, it should be noted that at least about 80 percent of the water utilities at all population ranges, with the exception of range 15,001-25,000 permitted a minimum of less than 5,000 gallons of water per month.

Table 32. Volume of Water Allowed in the Minimum Charge by Water Utilities by Population Served and Ownership in Louisiana, 1971 1/

Population served	Gallons of water 2,000-2,999	3,000-3,999	4,000-4,999	5,000-above	Total number
	---------------Percent------------				
1 - 500	33.4	29.6	18.5	18.5	54
501 - 1,000	33.3	41.7	16.7	8.3	36
1,001 - 3,000	25.0	12.5	62.5	0	16
3,001 - 5,000	27.4	36.2	18.2	18.2	11
5,001 - 10,000	66.7	33.3	0	0	6
10,001 - 15,000	60.0	20.0	0	20.0	5
15,001 - 25,000	50.0	0	0	50.0	4
25,001 - 50,000	33.3	50.0	16.7	0	6
Above 50,000	14.3	28.6	42.8	14.3	7
Type of ownership					
Municipal	25.0	14.3	32.1	28.6	28
Private	23.1	23.1	30.7	23.1	52
FHA	47.8	41.5	10.7	0	65

1/ Based on a sample of 231 water utilities and excludes the 18 utilities that base the minimum on meter size.

Based on type of ownership, about 90 percent of the FHA water utilities permitted less than 4,000 gallons in the minimum. On the other hand, about 40 percent of the private and municipal water utilities allow this amount in the minimum.

Special Charges

Special charges, constitute an important source of revenue to water utilities and vary directly with the number of customers served by such utilities. Some of these charges are a fixed payment upon connection to a water service while others vary depending upon the nature of service provided. They relate to specific groups of customers, such as those living outside the city limits; to special uses such as fire protection, air-conditioning, and sprinkling; and to such services as installation of meters, service lines, tapping, and reconnection fees. The discussion of these services will be pursued as follows:

1. Outside area - limits charges,
2. Nonrecurrent charges,
3. Surcharges or demand charges, and
4. Fire protection charges.

Outside Area-limits Charge: In Louisiana, extra charges for outside the area-limits customers apparently is not a common practice for of the 231 water utilities which responded to the survey, only fifteen (7 percent) imposed such charges. These were all municipally-owned utilities and the additional outside charges ranged from \$1.00 to \$4.50 per 1,000 gallons of water (Table 33). Within this range, the charges varied by the amount of water consumed per month. Four water utilities, however, applied a flat percentage ranging between 25 to 30 percent of the monthly water bill to the outside limit customer. This procedure, appears inadequate since it may or may not meet the additional cost to serve this customer group. Its use results from the simplicity and ease of administration.

Table 33. Outside Area-limits Charges by Water Utilities in Louisiana, 1971 1/

Additional charges per 1,000 gallons per month	Number of utilities	Percent
$1.00 - 1.99	4	26.7
$2.00 - 2.99	2	13.3
$3.00 - 3.99	4	26.7
$4.00 - 4.99	1	6.6
25 - 30 percent of monthly bill	4	26.7
Total	15	100.0

1/ Based on a sample of 231 water utilities.

Of the 15 utilities, reporting the additional outside area-limits charge, all were located in urban areas and four served a population between 5,001-10,000, eight served between a range of 10,001-25,000, while the remaining three served greater populations reaching as high as 560,000 in New Orleans.

There is still an unresolved controversy with regards to charges for water supplied to customers outside the orginal geographic boundaries served by a water utility. Normally, those living outside the area-limits are required to pay higher charges since the initial establishment and design of water system did not make provisions for such customers.[13] Being at greater distances and usually scattered over a wider area, outside customers must pay added costs to a water utility for plant expansion, pumping, and distribution of water mains.[14] Where this differential is not imposed, however, the inside area customers must subsidize the outside area customers.

Charging the same price to both groups of customers poses some serious questions among municipally owned water utilities. Generally, taxpayers living inside the area-limits contribute directly to the financial support of the municipal water utility through water rates and indirectly through taxes. Therefore, when price increases as a result of additional costs incurred by serving outside area customers, inside customers are required to pay more than a just share of these costs.

On the other hand, it may be argued that extension of water services to outside area customers will expand the operations to achieve greater economies of scale and result in a lower average cost of production. Accordingly, if this lower cost is translated into lower prices then both inside and outside customers will benefit.

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[13] Albert P. Learned, "Determination of Municipal Water Rates," Journal of American Water Works Association, Volume 49, No. 2, February 1957, pp. 165-173; and F. Burton Smith, "Establishment of Rate Differentials Inside and Outside City Limits," Journal of American Water Works Association, Volume 44, No. 2, February 1952, pp. 142-148.

[14] Melvin P. Hatcher, "Distance and Demand Factors in Suburban Water Rates," Journal of American Water Works Association, Volume 42, No. 11, November 1950, pp. 1,003-1,008.

Nonrecurrent Charges

Tapping Fee: A tapping fee is charged for the connection of water mains to the customer's residence. It is independent of water consumption and is a one time charge nonreimbursable to the customer upon termination of water service.

Of the 152, water utilities reporting tapping fees, the charge ranged from a low of $10.000 to a high of $50.000 with the common charge of $25.00 imposed by 56 percent of the water utilities.

Table 34 indicates that there is no relationship between population served and the level of tapping fee charged. This results from the fact that its a flat charge based upon labor and material costs involved with connecting water service to a customer's residence.

On the basis of ownership, Table 34 reveals that more than half of the municipal water utilities reporting charged a tapping fee of more than $30.00.

Among the private and FHA water utilities, however, 63.2 percent of the former and 91.4 percent of the latter charged below $30.00.

Customer Deposits: Customer deposits, commong among water utilities, provide a temporary source of revenue since they must be reimbursed, to the customer upon termination of water service, except where deductions are made for delinquent accounts or breakage or destruction of a water utility's property. A customer deposit, therefore, serves as a guarantee or safeguard in avoiding financial losses

Table 34. Distribution of Utilities by Tapping Fee, by Population Served, and by Ownership of Water Utilities, Louisiana, 1971 1/

Population served	Tapping fees								Total
	$10.00-$19.99		$20.00-$29.99		$30.00-$39.99		$40.00 and above		
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number
1 - 500	7	11.1	39	61.9	9	14.3	8	12.7	63
501 - 1,000	1	3.8	17	65.4	6	23.1	2	7.7	26
1,001 - 3,000	4	19.0	10	47.6	4	19.0	3	14.4	21
3,001 - 5,000	3	19.9	4	26.7	4	26.7	4	26.7	15
5,001 - 10,000	1	11.1	4	44.5	1	11.1	3	33.3	9
10,001 - 15,000	1	16.6	3	50.0	-	0.0	2	33.4	6
15,001 - 25,000	-	0.0	4	66.7	-	0.0	2	33.3	6
Above 25,000	-	0.0	4	66.7	-	0.0	2	33.3	6
Total	17	11.1	85	55.9	24	15.8	26	17.2	152
Ownership									
Municipal	5	13.2	12	31.6	9	23.6	12	31.6	38
Private	10	14.7	33	48.5	11	16.2	14	20.6	68
FHA	2	4.3	40	87.1	4	8.6	0	0.0	46
Total	17	11.1	85	55.9	24	15.8	26	17.2	152

1/ Based on a sample of 231 water utilities.

through "bad" accounts. Some utilities make interest payments on the deposits held during the course of supplying water service.

All utilities having a system of metered rates, in this study, required customer deposits ranging from $5.00 to 30.00, with 78 of the 163 utilities requiring deposits in the range of $20.00 to 30.00. No customer deposits were reported by the 55 water utilities which have flat rates.

By types of ownership, it was noted that most private and municipal utilities asked for a deposit within the range of $10.00-19.99, while the FHA water utilities required deposits in the range of $20.00 to 30.00 (Table 35).

Table 35. Distribution of Water Utilities by Size of Customer Deposits, by Population Served, and by Ownership, Louisiana, 1971 1/

Classification	Customers' deposits			Total
	$5.00-9.99	$10.00-19.99	$20.00-30.00	
	- - Number of water utilities - -			
Population served				
1 - 500	5	16	44	65
501 - 1,000	3	11	21	35
1,001 - 3,000	8	8	11	27
3,001 - 5,000	4	3	1	8
5,001 - 10,000	4	6	1	11
10,001 - 15,000	3	1	--	4
15,001 - 25,000	3	2	--	5
Above 25,000	3	5	--	8
Total	33	52	78	163
Ownership				
Municipal	12	27	7	46
Private	21	25	6	52
FHA	--	--	65	65
Total	33	52	78	163

1/ Based on a sample of 231 water utilities.

Meter Installation Charge: Some water utilities require payment for installation of meters at the customer's residence. Although commonly imposed as a direct charge, some water utilities incorporate it as part of a customer's deposit.

Of the 163 water utilities reporting a system of metered rates, 30 imposed meter installation charges ranging from a minimum of \$10.00 to a maximum of \$25.00. Actually, 25 of the 30 utilities having meter installation charges were private water utilities. Private organizations seemingly have a greater need for these additional revenues in comparison to municipal water utilities.

FHA water utilities, as reflected by the survey, do not impose a direct charge for the installation of meters. Apparently, the charge is partially incorporated in the customer's deposit or the generally higher rates imposed by the FHA.

Reconnection Fees: Reconnection fees are imposed on customers who resume water service after interruption because of failure to pay the monthly water bill. Such customers not only pay a reconnection fee, but may be subject to a penalty for late payment. The reconnection fee is normally set at a level to recover the costs incurred in restoring water service.

Table 36 shows the number of utilities charging different levels of reconnection fees by population and ownership of water utilities. Of the 100 water utilities reporting, 65 had a reconnection fee ranging between \$3.00-5.99. Based on ownership, 56 percent of private water utilities had this fee in contrast to 44 percent of municipal utilities and none of the FHA utilities.

Table 36. Distribution of Water Utilities by Reconnection Fees, by Population Served, and Ownership, Louisiana, 1971 1/

Classification	Reconnection fees			Total
	$1.00-2.99	$3.00-5.99	$6.00 and above	
	- - Number of water utilities - - -			
Population served				
1 - 500	4	18	7	29
501 - 1,000	3	10	2	15
1,001 - 3,000	4	14	3	21
3,001 - 5,000	-	7	2	9
5,001 - 10,000	2	4	1	7
10,001 - 15,000	1	3	-	4
15,001 - 25,000	1	5	-	6
Above 25,000	4	4	1	9
Total	19	65	16	100
Ownership				
Municipal	15	25	4	44
Private	4	40	12	56
FHA	--	--	--	--
Total	19	65	16	100

1/ Based on a sample of 231 water utilities.

Surcharges or Demand Charges

Surcharges or demand charges normally relate to water used for water-cooled air-conditioning, and lawn sprinkling. At times, it may include other special uses such as swimming pools and golf courses. These uses place a high demand on the water system due to their diurnal and seasonal variations. For example, lawn sprinkling is not only common in the afternoons, but is performed on a larger scale during the summer months. Therefore, it is argued that special charges be imposed for such water uses because they introduce additional costs which must be covered by rates charged for water uses, i. e., users must pay for the extra capacity required to meet peak demands.[15]

To avoid an excessive demand on the system, some water utilities apply restrictions to water used by imposing controls rather than raising the price of water. For example, some water utilities restrict the size of water-cooled air-conditioners or require a license for the installation of such air-conditioners, while others ask consumers to provide water conserving devices such as a cooling tower, whereby water is recycled several times before discharge.[16]

As reflected by the survey, two water utilities reported a charge of $1.28 per ton per month for air-conditioning and two others a flat charge of $3.50 per month for lawn sprinkling. These four water utilities were municipally owned and served urban populations above 15,000. Water for air-conditioning is primarily used by commercial or small industrial establishments while lawn sprinkling is generally carried on for residences and charged at the prevailing domestic water rates.

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[15] Hyman H. Gerstein, "Impact of Water Use for Air-Conditioning on Chicago's Water System," Journal of American Water Works Association, Volume 49, No. 6, June 1957, pp. 697-704; and J. R. Pierce, "Demand Charge for Air-Conditioning Use in Arkansas," Journal of American Water Works Association, Volume 45, No. 8, August 1958, pp. 870-872.

[16] C. K. Matthews, "Meeting Air-Conditioning Growth," Journal of American Water Works Association, Volume 46, No. 7, July 1954, pp. 662-666.

As mentioned above, the use of water for air-conditioning and lawn sprinkling places a great demand on the capacity of the water utility. A flat charge for these uses places little restraint on water use; thus, waste and careless use of water are encouraged and additional capacity-costs in plant facilities are incurred.

Fire Protection Charges

Water utilities usually distinguish between "public" and "private" fire protection. The former relates to general fire protection for the entire community and is regarded as a social obligation. This obligation has been established by court decisions, one of which states that,

> . . . any water utility whether municipally owned or investor owned (private), has a legal liability to property owners who suffer fire losses as a result of negligence in the operation or maintenance of fire hydrants.[17]

Although public fire protection is a community service, certain individual establishments such as commercial or industrial enterprises may request private fire protection. Installation of hydrants and reservation of a specific volume of water for private use assures a minimum amount of water in the event of a fire.

Of the 231 water utilities responding to the survey, 63 reported a charge for "public" fire protection and six reported a charge for "private" fire protection. This latter group served populations above

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[17] John H. Murdock, "Recent Decisions on Utility Liability for Fire Protection," Journal of American Water Works Association, Volume 58, No. 6, January 1966, pp. 17-18.

15,000; four were municipally owned and charged $50.00 per year per hydrant; and two were privately owned and charged $120.00 per year per hydrant; four were located in the southwest WRPA and two in the south central WRPA.

"Public" fire protection was reported by 63 water utilities, 52 of which were municipally-owned, and 11 privately-owned. The most common charge of $25.00 per hydrant per year by municipal water utilities was less than $50.00 per hydrant per year charged by private water utilities. Moreover, 22 of the municipal utilities provided fire protection free of charge. This free service is often accorded in return for tax concession or municipal funding. In a technical sense, there is no such thing as free fire protection. Generally, municipal water utilities are not entirely dependent on revenues obtained through water rates but receive subsidies from the municipal government.

The FHA water utilities in Louisiana, as revealed by this study, reported no charge either for public or private fire protection. Such a service would entail a heavy cost on water customers who are already paying the highest rates in the state for residential water supplies.

Since density of population is closely associated with public fire protection, it is important to examine its influence in Louisiana. Of the 63 water utilities reporting the service, all served populations above 5,000 and 50 percent served population of more than 15,000. In addition, these populations were located in urban areas not only characterized by large numbers, but also by greater density which is a critical factor in the determination of the number and location of fire hydrants.(Table 37).

Table 37. Distribution of Water Utilities by Charges for "Public" Fire Protection, by Population Served, and by Ownership, Louisiana, 1971 1/

Classification	Charge per hydrant per year				Total
	$10.00	$25.00	$50.00	Free of charge	
	- - - - Number of utilities - - - - -				
Population served					
1 - 500	--	--	--	--	--
501 - 1,000	--	--	--	--	--
1,001 - 3,000	--	--	--	--	--
3,001 - 5,000	--	--	--	--	--
5,001 - 10,000	2	7	--	--	9
10,001 - 15,000	3	6	2	2	13
15,001 - 25,000	--	4	5	5	14
Above 25,000	--	5	7	15	27
Total	5	22	14	22	63
Ownership					
Municipal	5	18	7	22	52
Private	--	4	7	--	11
FHA	--	--	--	--	--
Total	5	22	14	22	63

1/ Based on a sample of 231 water utilities.

Based on this survey, two common water utility practices with respect to charges for fire protection are observed. First, rates charged for private customer fire protection are generally higher than rates for public fire protection, whether the service is provided by a municipal or private water utility. The economic justification for this difference in charges is based on: (a) private fire protection service is designed for specific demands of private customers and consequently results in a higher cost and price for the service; (b) public fire protection provides public benefits and, therefore, a lower price is accorded in the interest of public welfare.

Second, when ownership of water utilities is considered, rates charged, are generally lower among municipal water utilities than in private water utilities. Rates of private water utilities are higher because: (1) private water utilities are not accorded exemption from taxes as for municipal water utilities, (2) private water utilities depend solely for their economic survival on revenues generated from operation of the water utility, whereas municipal water utilities are not normally required to do so, and (3) the level of revenue of a private water utility is expected to provide a fair return on investment. The latter is generally not expected of municipal water utilities.

Although, as shown here, the level of fire protection charges depend on the group of individuals receiving benefits and the type of ownership of the water utility, there are certain other factors which influence the determination of the level of such charges. Two of these factors are: (1) the water utility is expected to have a large, adequate and reliable water supply, and (2) the water utility must be ready to furnish the service at any moment in time. In light of this, water utilities must maintain an excess capacity of water supply, the costs of which are not customarily reflected in the rates charged for fire protection, but rather in higher water rates to consumers in general. Costs of fire protection may also be less evident where a property tax is used to finance the costs of fire protection within a municipality. However, the argument runs that as a social service, the value of fire protection cannot be measured by the amount of water used and for this reason charges are estimates based on the number of fire hydrants in a community.[18]

Financial Status of Water Utilities

The residential water industry as reflected by this survey, is characterized by a large number of water utilities (firms) selling a homogeneous commodity. Despite the large number of water utilities, each possesses a local monopoly in a limited market in which competition is regulated by nonmarket forces and consequently the price charged for water is not an equilibrium price determined by supply and demand conditions of the market. The price is determined by a delegated governmental authority that supposedly takes into consideration the social and economic factors which affect the industry. Because of this, the financial status of each water utility, and likewise the industry, becomes a fundamental consideration in determining the ability of the utility to survive and, more important, its ability to attract capital for future investment needs. However, the level of future investment is contingent upon the rate of return generated by the current economic

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[18] Preston A. Reynolds and George K. Good, "Fire Protection Service Charges," Journal of American Water Works Association, Volume 42, No. 4, April 1950, pp. 333-340.

operations of each water utility. If the current operations of water utilities result in a "fair" return, then the future of the water industry is in no immediate economic jeopardy. However, when less than a fair return is realized some economic adjustments, either in costs of water production or the price charged for water, are in order to insure future economic survival.

Economic survival of a water utility is contingent upon a level of revenue necessary at least to offset the costs of production. The level of revenue depends on the price charged and the quantity of water sold at a given point in time. Since water prices are regulated by government, the most a water utility can do to increase its level of revenues is to increase the quantity of water sold to customers. However, this may be difficult with the number of customers currently served by a water utility, since residential water consumption per customer is to a large extent invariable. The amount of water sold, therefore, can only increase by creating new demands on the part of existing customers or by expanding the market to involve new customers.

Faced with the situation of a regulated price and relative invariability of the quantity water sold, water utilities, therefore, must pay particular attention to their costs of production if economic survival is to be feasible. Emphasis will have to be placed on the efficient use of the resources which enter into water production in order to produce at an average cost at least equal to the average revenue of the water utility. Since increases in water cost may not be readily incorporated into increased water rates, efficient operations of the water utility will be contingent upon management of supply and not of demand.

As shown previously, the average family consumption per month is estimated at 10,000 gallons. The average price charged for 10,000 gallons was $6.74 by municipal water utilities, $7.90 by private, and $10.08 by the FHA water utilities. Generally, it is expected that apart from the fact that water rates are regulated, these prices to a large extent reflect the costs of water production. The lowest price charged by municipal water utilities results from economies of scale by serving larger and denser populations, or by subsidies provided by the municipal government. FHA water utilities on the other hand serve scattered rural populations and this accounts primarily for higher costs and higher prices of water, primarily those costs associated with distribution which reached as much as 50 percent of the total cost of operation. Private water utilities serve both rural and urban areas and it is expected that their costs and prices should range between those of municipal and FHA water utilities.

Based on the cost-price relationship of these water utilities, their economic survival depends upon the net income generated from their operations. Net income represents the difference between total revenue and total costs. Total revenue is derived from water sales and related services. Total costs consist of variable cost and fixed costs. Variable costs include those costs associated with maintenance and repairs, pumping, water treatment, transmission and distribution, and customer accounting and collecting. Fixed costs include depreciation, taxes, insurance, rent, and interest charge.

In Louisiana, as reflected by responses of 210 utilities which provided a statement of financial conditions 66.7 percent realized a net income and 33.3 percent a net loss in 1971 (Table 38). A net loss by one out of three utilities implies that the prices charged for water, by these water utilities, failed to generate sufficient revenue to meet costs of production. Although not shown in Table 38, it was found, however, that all the water utilities received sufficient revenue to cover the variable or operating costs of production. Under this condition a water utility can continue to operate in the short-run, but in the long-run both variable and fixed costs of production have to be recovered for economic survival.

<u>Net Income and Net Loss of Water Utilities</u>: Apart from the general financial picture of the water utilities, a more meaningful comparison can be obtained by examining the net income or net loss by population served. As shown on Table 38 all water utilities serving a population between 15,001-25,000, realized a net income. In addition, 75.0 percent of those water utilities that serve populations between 1,001-2,000 and above 25,000 also realized a net income. However, at a population range of 3,001-5,000 half the water utilities realized a net income and the other half a net loss. Apart from the latter group, the largest percentage of water utilities which suffered losses were those that served populations ranging between 5,001-10,000 and 1,000 or less. From this analysis, therefore, it is evident that serving a population of above 15,000, seems to provide greater probabilities of realizing a

Table 38. Number and Percent of Water Utilities Having a Net Income or Net Loss, Based on Population Served, Type of Ownership, and Regional Location, Louisiana, 1971 1/

Classification	Net income: Number of utilities	Net income: Percent	Net loss: Number of utilities	Net loss: Percent	Total number
Population served					
1 - 500	62	64.6	34	35.4	96
501 - 1,000	27	64.3	15	35.7	42
1,001 - 3,000	24	75.0	8	25.0	32
3,001 - 5,000	4	50.0	4	50.0	8
5,001 - 10,000	6	60.0	4	40.0	10
10,001 - 15,000	4	66.7	2	33.3	6
15,001 - 25,000	4	100.0	-	0.0	4
25,001 - 50,000	3	75.0	1	25.0	4
Above 50,000	6	75.0	2	25.0	8
Total	140	66.7	70	33.3	210
Type of ownership					
Municipal	24	60.0	16	40.0	40
Private	57	53.3	50	46.7	107
FHA	59	93.6	4	6.4	63
Total	140	66.7	70	33.3	210
Regions					
Southeast	8	57.1	6	42.9	14
South Central	27	57.4	20	42.6	47
Southwest	28	71.8	11	28.2	39
Northeast	16	66.7	8	33.3	24
North Central	25	64.1	14	35.9	39
Northwest	36	76.6	11	23.4	47
Total	140	66.7	70	33.3	210

1/ Based on a sample of 231 water utilities.

net income as against a net loss.

Based on ownership, the water utilities whose operations are most profitable are those that are FHA owned where 93.6 percent realized a net income in 1971. On the other hand about 47 percent of the private water utilities and 40 percent of the municipal utilities showed losses. The relatively good financial condition of FHA water utilities is not surprising since they all have metered consumption and the rates charged by these water utilities are relatively high. By constrast, of the 55 water utilities which reported the use of flat rates, 85.5 percent were privately owned and, 87.2 realized a net loss in 1971. Flat rates offer no restriction on water consumption and at the same time encourages careless use.

Based on regional location, it is shown that the largest percentage (76.6) of water utilities in Northwest Louisiana realized a net income in 1971. This large percentage reflects the fact that the largest number of FHA water utilities are located in this region. On the other hand, the southeast and south central regions having the largest percentages of utilities with net losses are also the regions where most private water utilities are located.

Recognizing that some water utilities incurred a net loss and others a net gain, the important question is the size of the gain or loss. Of the 140 Louisiana water utilities in the sample which reported a net income in 1971, 89 (64 percent) realized a net of $5,000 or less (Table 39). Generally, it is expected that as population served

Table 39. Net Income Realized by Water Utilities in Louisiana by Population Served, Type of Ownership, and Regional Location, 1971 1/

Classification	Net income (dollars)					Total
	0-1,000	1,001-5,000	5,001-10,000	10,001-25,000	Above 25,000	
	- - - - Number of water utilities - - - -					
Population served						
1 - 500	21	38	2	1	--	62
501 - 1,000	4	12	10	1	--	27
1,001 - 3,000	2	9	5	7	1	24
3,001 - 5,000	1	--	--	3	--	4
5,001 - 10,000	--	--	2	2	2	6
10,001 - 15,000	1	1	--	2	--	4
15,001 - 25,000	--	--	1	2	1	4
25,001 - 50,000	--	--	1	1	1	3
Above 50,000	--	--	--	--	6	6
Total	29	60	21	19	11	140
Type of ownership						
Municipal	3	4	4	4	9	24
Private	24	15	3	13	2	57
FHA	2	41	14	2	--	59
Total	29	60	21	19	11	140
Regions						
Southeast	-	5	1	-	2	8
South Central	11	11	4	-	1	27
Southwest	5	8	5	7	3	28
Northeast	1	5	3	5	2	16
North central	5	15	5	--	--	25
Northwest	7	16	3	7	3	36
Total	29	60	21	19	11	140

1/ Based on a sample of 231 water utilities.

increases, the average cost of production will decrease because of economies of scale. Accordingly, net income should increase given the established rate of the regulatory commission. This is borne out by the sample of water utilities which reported a net income in 1971. The average net income for all water utilities in the state was estimated at $5,000 during 1971.

Based on types of ownership, about 50 percent of municipal water utilities realized a net income of $10,000 or more whereas for the FHA utilities about 97 percent realized less than $10,000, and 68 percent of private utilities realized less than $5,000 net income.

This relatively small amount of net income to private water utilities is quite a dilemma in terms of expansion or future growth of these water utilities. Generally, private water utilities have to seek outside financing for new capital investment and, unless the profit is there, future operations of these water utilities may be adversely affected. FHA water utilities are somewhat less dependent on commercial financing, and municipal water utilities can be financed by the selling of municipal bonds or by other municipal funds. It is rather noteworthy that municipal water utilities had the highest level of net income, although municipal water utilities charge the lowest rates. This undoubtedly reflects economies of scale and perhaps municipal subsidies on some costs.

In terms of net losses, Table 40 indicates that of the 70 water utilities reporting losses in 1971, 84.3 percent (59) realized a net loss of $5,000 or less. Actually the largest number (32) realized a

Table 40. Number of Water Utilities Reporting Net Losses, by Population Served, Type of Ownership, and Regional Location, Louisiana, 1971 1/

Classification	Net loss (dollars) 0-1,000	1,001-5,000	5,001-10,000	10,001-25,000	Above 25,000	Total
	- - - - Number of water utilities - - - -					
Population served						
1 - 500	26	8	--	--	--	34
501 - 1,000	5	10	--	--	--	15
1,001 - 3,000	1	4	1	2	--	8
3,001 - 5,000	--	2	2	--	--	4
5,001 - 10,000	--	2	--	1	1	4
10,001 - 15,000	--	1	1	--	--	2
15,001 - 25,000	--	--	--	--	--	--
25,001 - 50,000	--	--	--	--	1	1
Above 50,000	--	--	--	--	2	2
Total	32	27	4	3	4	70
Type of ownership						
Municipal	2	5	3	2	4	16
Private	28	20	1	1	--	50
FHA	2	3	--	--	--	4
Total	32	28	4	3	4	70
Regions						
Southeast	1	1	1	--	3	6
South Central	9	9	1	1	--	20
Southwest	2	6	2	1	--	11
Northeast	5	3	--	--	--	8
North Central	9	5	--	--	--	14
Northwest	6	3	--	1	1	11
Total	32	27	4	3	4	70

1/ Based on a sample of 231 water utilities.

net loss of $1,000 or less. The average net loss for all water utilities surveyed was estimated at $3,000 during 1971.

Based on ownership, of the 70 water utilities reporting a net loss, 71 percent (50) were privately owned. Although, as mentioned previously, some municipal water utilities realized the highest level of net income, other municipal water utilities realized the heaviest losses, i. e., four municipal water utilities reported a net loss of $25,000 or more.

As mentioned earlier, the water rate structures appear to have a direct bearing upon the financial condition of water utilities. As shown in Table 41, of the 39 water utilities reporting the use of flat rates, 87.2 percent realized a net loss. By way of contrast, 81.3 percent of those water utilities using metered rates realized a net income. About an equal number of those using a combined flat and metered rate system experienced a net loss or net income.

Table 41. Number of Water Utilities Experienced a Net Income or Net Loss by System of Water Rates, Louisiana, 1971 1/

Type of water rates	Net income		Net loss		Total number
	Number of utilities	Percent	Number of utilities	Percent	
Flat rates	5	12.8	34	87.2	39
Metered rates	130	81.3	30	18.7	160
Flat and metered rates	5	45.5	6	54.5	11
Total	140	66.7	70	33.3	210

1/ Based on a sample of 231 water utilities.

Summary

In summary, it can be stated that a system of metered rates used by water utilities, outnumbers the use of flat rates by 3 to 1. Very few water utilities, (5.6 percent) used a combined system of metered and flat rates and these utilities generally served an average population of 10,000, which indicates that this is the level of population at which a change from a flat rate system to a metered system appears economically feasible.

The use of flat rates in Louisiana is most common among privately owned water utilities, most of which are located in the south central WRPA. Although a few municipal water utilities still use flat rates, the general pattern is to use metered rates. No FHA water utility uses flat rates. Flat rates where used ranged from a minimum of $1.50 to $7.50 per month with $4.00 being the most common charge.

Generally, water utilities which use flat rates serve relatively small populations of 500 or less. However, water utilities with metered rates were common at all levels of population.

With metered rates, the common pricing policy was based on the "declining block" principle where, as the volume of water consumption increases, price per successive blocks become lower. The difference in price between the second block and last block was greatest among municipal water utilities where the price of the last block was about one-third that of the second block. On the other hand, for private water utilities it was two-fifths, and for the FHA water utilities it was two-thirds. Taking account of these differences, the average price for 10,000 gallons of water, which represents the average family consumption per month in Louisiana, was computed to be \$6.74 for municipal water utilities, \$7.90 for private water utilities and \$10.08 for FHA water utilities.

A significant trend observed in the use of declining block rates by water utilities in the sample, was the incorporation of the minimum charge in the price of the first block. With the exception of 8 percent of the water utilities where the minimum charge was contingent upon meter size, the average minimum charge was \$4.00 per month, with the minimum decreasing as the size of the market increased. Since municipal water utilities serve generally large urban populations, the minimum charge was lowest (\$3.00 or less) among municipal water utilities and highest (\$5.01-7.00) among FHA water utilities. In addition, the volume of water included in the minimum was lowest among FHA water utilities (2,000-3,000 gallons per month) and highest among municipal and private water utilities (4,000-6,000 gallons per month).

Other charges for water service by water utilities in the sample were outside area-limits charges, nonrecurrent charges, surcharges, and fire protection charges. Nonrecurrent charges included the tapping fee, customer's deposit, meter installation and reconnection charges. The tapping fee ranged from \$10.00 to \$50.00 with the most common charge being \$25.00. The average charge for meter installation was \$15.00 and was more predominant among the private water utilities.

Surcharges by water utilities in the sample, relate to water use for air-conditioning and lawn sprinkling. A direct charge for these water uses was reported by four municipal water utilities and the average charge for air-conditioning was $1.28 per ton per month while a charge of $3.50 was made for lawn sprinkling.

"Public" fire protection charges were more common than "private" fire protection charges, based on the water utilities surveyed. Charges for public fire protection ranged from $10.00 to 50.00 per hydrant per year whereas for private fire protection the range was $50.00 to 120.00 per hydrant per year. It should be noted that 22 municipal water utilities provided public fire protection free of charge.

In terms of the financial status of water utilities, two out of three realized a net income from their operations in 1971. Based on ownership, about 94 percent of the FHA water utilities showed a net income whereas 60 per cent of the municipal and 53 percent of the private water utilities reported net incomes. Net income of all water utilities averaged about $5,000 during 1971. Sixty-four percent of the water utilities reported a net income of $5,000 or less. Municipal water utilities reported the highest level of net incomes as well as the greatest level of net losses. By contrast, private water utilities reported the lowest level of net income as well as losses. Based on the system of water rates uses, 81.5 percent of the water utilities which have metered rates gained a net income whereas those which use flat rates 87.2 percent realized a net loss. Such conditions indicate that the price charged for residential water use do not fully reflect the costs of providing the service. Unless, the price charged is consistent with rising costs of water production, it is likely that a larger number of water utilities in Louisiana will find it difficult to survive economically.

CHAPTER VI

THE PRICING OF WATER IN AGRICULTURE

Introduction

The importance of having an adequate quantity of water at the appropriate time is probably nowhere better demonstrated than in its use for agriculture. Deficiency in water supplies in the form of droughts, or excessive quantities in time of floods, adversely affect the cultivation of agricultural crops. Actually, an adequate supply of water is considered the most important input in the process of agricultural production apart from the land. Productivity of land without water is practically nil. Thus, it may be said that productivity is to a large extent governed by the use of water which is characterized by a natural uncertainty in the variability of rainfall. Coupled with the seasonality of agricultural production, this uncertainty of precipitation has led to the development of elaborate irrigation structures designed to synchronize the supply and demand for agricultural water supplied by irrigation may be regarded as synonymous to total water use in agriculture.

The development of irrigation in agriculture generates economic benefits, primarily by increasing food production, improving employment and promoting rural development. Not all irrigation, however, is beneficial economically, for there are systems which are uneconomic as well. Bamesberger claims water losses can reach about three-quarters of total water intake by agriculture, and therefore warned that the decision to invest in an irrigation system must be carefully evaluated by the prospective farmer in terms of the difference between its economic costs and the benefits likely to be received.[1]

The costs of irrigation depend on land topography, the source of water supply, the distance between the farm and the water source, and the method of irrigation. Two systems of irrigation are commonly used - sprinkler systems and flooding systems. Flooding systems require a smaller level of capital investment per acre when used on flat land, but where land is uneven, a higher level of investment per acre may be expected. Apart from this, the major cost factor relates to the source of water, i.e., surface or ground water. Water obtained from ground sources is considered more costly than surface water with the cost difference resulting from the development, operation and maintenance of wells and pump equipment.

In evaluating the costs of irrigation, the traditional approach is to separate total costs into its fixed and variable components. The annual fixed costs are based on the expected life of the equipment and includes annual depreciation allowances, interest charges, rent, and allowances for taxes, risk, and insurance. The most common method for computing annual fixed costs is to use: (1) straight line depreciation,

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[1]J. G. Bamesberger, "Preparing Land for Efficient Irrigation," in Water: The Yearbook of Agriculture, 1955 (Washington: U. S. Government Printing Office), 1955, p. 279.

(2) an appropriate interest rate, such as six percent on the initial investment, (3) any rental charges, and (4) an allowance, of say three percent, of the initial investment for taxes, risk, and insurance. The variable costs generally include costs for repairs, maintenance, labor, and energy requirements of the specific irrigation system. Once the system is established, energy costs, depending on its price per unit and the quantity used, are considered the largest fraction of variable costs of the system. However, as a proportion of total costs, the variable costs are usually a minor component in comparison to fixed costs.

Supply and Demand Characteristics of Agriculture Water Use in Louisiana

The supply and demand for water by Louisiana agriculture has been a consistent problem over recent years, both with respect to ground and surface supplies. This was noted by Wiegmann in 1956, who claimed that, "while our annual rainfall in Louisiana is relatively high, averaging about 56 inches . . . the uneven distribution results in periods of dry weather or droughts which can be highly detrimental to crop yields."[2] In addition to this, the ground water table in some of the agricultural areas of the state, specifically in the southwest rice area, has been considerably lowered due to excessive pumping, to the extent that salt water intrusion appears imminent during the irrigation

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[2]Fred H. Wiegmann, "Drought and the Need for Supplemental Irrigation in Louisiana," Louisiana Rural Economist, Volume XVIII, No. 4, November 1956, p. 1.

season.[3]

Agriculture ranks second in the state's total water use, accounting for 603.6 billion gallons in 1967, of which 580.9 billion gallons (96 percent) were used in irrigation. Of this latter amount 576 billion gallons were devoted to irrigation for the production of rice and this explains why the southwest area accounted for 563.4 billion gallons (93.3 percent) of the state's total water use in agriculture (Table 42). Because of this large percentage of water used for irrigation in southwest Louisiana, agricultural water costs and pricing in Louisiana may be analyzed and evaluated in terms of irrigation water used in the cultivation of rice. The supply of water for other agricultural uses resolves into minor domestic uses supplied largely by individual shallow wells and natural surface waters.

The supply of water for rice irrigation is obtained from both ground and surface water sources with the larger proportion obtained from the latter source. In 1965 total pumpage amounted to 1,379.2 million gallons a day (MGD) with 565.2 MGD obtained from ground sources and 814.0 MGD from surface sources.[4] In 1970 pumpage of water totalled 1,530.0 MGD, of which 750.0 MGD were supplied by ground sources and

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[3]A. H. Harder, Chabot Kilburn, H. M. Whitman, and S. M. Rogers, "Effects of Ground-Water Withdrawals on Water Levels and Salt Water Encroachment in Southwestern Louisiana," Water Resources Bulletin No. 10, (Baton Rouge: Department of Conservation, Louisiana Geological Survey and Louisiana Department of Public Works), October 1967, p. 1.

[4]P. P. Bieber and M. J. Forbes, "Pumpage of Water in Louisiana, 1965," Water Resources Pamphlet No. 20, (Baton Rouge: Department of Conservation, Louisiana Geological Survey and Louisiana Department of Public Works), August 1966, pp. 6-7.

Table 42. Total Agricultural Water Use by Water Resource Planning Areas in Louisiana, 1967

Region	Water used 1/	Percentage of total
	Million gallons	
Northwest	2,977.2	0.5
North Central	8,292.0	1.4
Northeast	23,281.0	3.9
Southwest	563,415.7	93.3
South Central	3,031.1	0.5
Southeast	2,619.8	0.4
State total	603,616.8	100.0

1/ Based on a conversion of 326,700 gallons per acre-foot.

Source: Gulf South Research Institute, Present Agricultural Water Use in Louisiana, Baton Rouge: Department of Public Works, Volume 11, Series 1, 1970, p. 5.

780.0 MGD by surface sources.[5] Based on this five year span, total pumpage of water for rice irrigation increased by 10.8 percent and the composition of this increased consisted of a greater proportion of water supplied from ground water sources which increased by 33 percent while supplies from surface sources declined by 4 percent. This trend in the use of more ground water for rice irrigation will, however,

[5] Don C. Dial, "Pumpage of Water in Louisiana, 1970." Water Resources Pamphlet No. 26, (Baton Rouge: Department of Conservation, Louisiana Geological Survey and Louisiana Department of Public Works), July 1970, pp. 8-9.

result in an increase in the average cost of water for rice irrigation since greater costs will have to be met, specifically for the establishment, operation and maintenance of wells assuming farmers have equal access to both sources of water. With the ground water table reaching critical low levels in southwestern Louisiana, this cost is likely to be further increased by having to drill deeper and deeper for fresh water supplies with the concomitant thrust of salt water intrusion.

The use of supplementary agricultural water in Louisiana, besides that for rice irrigation, is devoted to the production of vegetable crops, catfish, crawfish, livestock, and poultry. This group accounted for about 4.5 percent of total agricultural water use of the state, in comparison to rice which used 95.5 percent in 1967.

The demand for water in the production of rice, as well as in most agricultural crops, is of a seasonal nature, with the demand more pronounced in the late spring and early summer. This seasonal characteristic, coupled with the voluminous amounts required for irrigation of the rice crop, necessitates the development of large and elaborate irrigation systems. Because of this, irrigation systems are characterized at most times by a high degree of excess capacity. This cost of excess capacity must be borne by the farmer in the form of higher fixed costs than when irrigation systems are used at full-capacity.

In Louisiana, the rice season extends from April to August and, as expected, the demand for water for rice production is concentrated during this period. Moreover, the demand for water in rice production coincides with the pattern of total water use in the state, with the greatest consumption during the months of May and June. In 1967, the demand for these two months accounted for about 63.8 percent of total agricultural water used in rice cultivation, implying that the remaining 31.7 percent were used in the months of April, July, and August.[6]

Water supplies for rice irrigation in Louisiana are generally provided by water companies or by farm wells managed by the farm operators. Of the 576.3 billion gallons supplied in 1967, 208.5 billion gallons were provided by water companies, which in turn obtained most of the water from surface sources. On the other hand, self-supplied farmers provided 367.8 billion gallons with the major proportion obtained from ground water sources. However, due to a large amount of surface water also (162 billion gallons) provided by farmers themselves, water supplied for rice irrigation in Louisiana consisted of 62.2 percent surface water and 37.8 percent ground water (Table 43). These proportions or percentages are important from an economic standpoint to farmers, since "surface water is usually more economical than ground water and is preferred when large quantities are available."[7] Water used from ground sources generally is characterized by a degree of

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[6]Calculated from: Gulf South Research Institute, Present Agricultural Water Use in Louisiana, op. cit., p. 12.

[7]Willard Woolf and Joseph W. Freeland, Costs of Surface Pipeline Versus Subsurface Pipeline Irrigation, Southwest Louisiana Rice Area, (Baton Rouge: Louisiana Agricultural Experiment Station), D.A.E. Research Report No. 460, November 1973, p. 4.

Table 43. Irrigation Water Supplied for Rice Production by Water Resource Planning Areas in Louisiana, 1967 1/

Water resource planning area	Self-supplied		Water companies		Total		Total
	Ground	Surface	Ground	Surface	Ground	Surface	
	- - - - - - - - - - - - - - - - Million gallons - - - - - - - - - - - - - -						
Northwest	0	0	0	0	0	0	0
North Central	1,701.8	2,448.6	0	0	1,701.8	2,448.6	4,150.4
Northeast	13,664.9	4,315.4	0	0	13,664.9	4,315.4	17,980.3
Southwest	190,124.7	154,752.9	11,969.3	196,557.1	202,094.0	351,310.0	553,404.0
South Central	233.9	0	0	0	233.9	0	233.9
Southeast	0	535.8	0	0	0	535.8	535.8
State total	205,725.3	162,052.7	11,969.3	196,557.1	217,694.6	358,609.8	576,304.4
Percent of total supplied	35.7	28.1	2.0	34.2	37.8	62.2	100.0

1/ Based on a conversion of 326,700 gallons per acre-foot.

Source: Gulf South Research Institute, Present Agricultural Water Use in Louisiana, Baton Rouge: Department of Public Works, Series 1, Volume II, February 1970, p. 25.

uncertainty with respect to its location and depth, and the quantity and quality of supplies available. The quantity factor is of extreme relevance to rice production in southwestern Louisiana where the ground water table, as mentioned previously, has reached a critical level and intrusion of salt water into the aquifers already occurs during the irrigation season.

An interesting point in water used for rice irrigation in Louisiana is that larger amounts of water per acre of rice are used when water is supplied by water companies than by farmers themselves. Water supplied by water companies is estimated at 1.8 million gallons per acre whereas self-supplied farmers use 0.8 million gallons per acre.[8] Since the water served by both groups is used for the production of the same crop cultivated in the same geographical area, one may question the difference of one million gallons per acre of irrigated land. A reason for this difference may be that since canal companies give any amount of water needed at no extra cost, farmers use it liberally, whereas when it is pumped from wells, supplies are limited and used more efficiently.

In Table 44 the million gallons of water per acre of irrigated land for rice production is shown for six Water Resource Planning Areas of the state. Although variations occur among the regions, it is interesting to note the coefficient of 1.02 is applicable to the largest rice producing area of southwest Louisiana and also for the

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[8]Calculated from: Gulf South Research Institute, Present Agricultural Water Use in Louisiana, op. cit., p. 16.

Table 44. Irrigation Water Supplied and Acres of Irrigated Land for Rice by Water Resource Planning Areas in Louisiana, 1967

Water resource planning area	Total water supplied 1/	Acres irrigated	Coefficient
	Million gallons	Acres	Million gallons per acre
Northwest	0	0	
North Central	4,150.4	6,219	0.67
Northeast	17,980.3	14,564	1.23
Southwest	553,404.0	542,700	1.02
South Central	233.9	475	0.49
Southeast	535.8	820	0.65
State total	576,304.4	564,778	1.02

1/ Based on a conversion of 326,700 gallons per acre-foot.

Source: Gulf South Research Institute, Present Agricultural Water Use in Louisiana, (Baton Rouge: Department of Public Works, Series I, Volume II, February 1970), p. 9.

state as a whole. This is obviously a reflection of the direct influence which this region has on the pattern of water use, both for rice production and total agricultural water use in Louisiana.

An analysis of supply and demand for agricultural water in Louisiana leads to an evaluation of costs, and pricing. In this analysis, it is recognized that most of the water used in the Southwest region is fresh water, the greater part of which is obtained from surface water sources. Additionally, the demand is seasonal and water for agricultural use competes with demands from other uses, specifically industrial, in an area where seasonal shortages and salt water intrusion into the aquifers from the Gulf of Mexico has already been experienced.

Costs and Pricing of Irrigation Water

The use of agricultural water for irrigation in southwest Louisiana, depends on its price, the land acreage irrigated, the type of irrigation system used and the availability of water supplies. Although the number of irrigated farms has been decreasing in recent years, farm size and acreage under irrigation have increased. For example, between 1964-69 total irrigated land increased from 527,374 acres to 627,247 acres, and average farm size increased from 152 to 176 acres.[9] Apart from the increase in irrigated land, however, it should be noted that in 1964, acreage of irrigated land in the southwest WRPA accounted for 91 percent of all irrigated land in the state, whereas in 1969, this percentage decreased to 89 percent.

If the increasing trend in acres of irrigated land continues, the demand for irrigation water will also increase. Moreover, the pattern of water use and distribution in this area will undergo some changes resulting from the increases in farm size. Larger farms should allow a reduction in the average cost of water to self-supplied farmers whose greatest burden from investments in the irrigation system lies in its fixed costs. The onus of heavy fixed costs, is a critical element to

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[9] Calculated from U. S. Bureau of the Census, Census for Agriculture, 1969, Volume 2, Area Reports, Part 35, Louisiana; County Data, (Washington: U. S. Government Printing Office), 1972.

the farmer, when compared to the proportionally smaller variable costs for energy and maintenance once the irrigation system is established.

Of the two common methods of irrigation (the sprinkler system and flooding), flooding has increased proportionately more than sprinkling over the last two decades. As Wiegmann noted in a research study in the 1950's, flooding tripled while sprinkling doubled during 1953-55.[10] This preference for flood type irrigation may be explained by the lower average cost associated with flooding systems because of greater efficiency gained in land leveling, the greater expansion of irrigation on flat lands, and the ability to cover more acreage with less labor.[11] Economic justification for investment in either system, however, does not rest solely with the level of its average costs, but also on the economic returns generated by the respective systems.[12]

Regardless of the system chosen, the common method of rice irrigation is by surface canal and more recently there has been a move to subsurface pipelines. Freeland claims many farm managers have changed, or are contemplating a change from conventional surface canal irrigation of rice and other irrigated acreage to subsurface pipeline irrigation. In 1970, 168 newly constructed pipeline irrigation

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[10] Fred H. Wiegmann, "Supplementary Irrigation in Louisiana," Louisiana Rural Economist, Volume XVIII, No. 2, May 1956, p. 2.

[11] Ibid.

[12] Fred H. Wiegmann and Bill Bolton, "A Preliminary Discussion of Crop Irrigation in Louisiana," Louisiana Rural Economist, Volume XVI, No. 2, February 1954, p. 6.

systems were in operation in the four major rice producing parishes.[13] In light of this development, a comparative cost analysis was carried out by Woolf and Freeland, using both surface and ground water sources, also taking into account the desirability and serviceability of the two methods of irrigation.

Woolf and Freeland noted there was a significant difference in the level of total fixed investment incurred in the establishment of a surface canal and a subsurface pipeline to supply water to a 136.5 acre rice farm.[14] Investment in the surface canal was estimated at $2,395.15 ($0.59 per linear foot) and in the subsurface pipeline $11,728.44 ($3.34 per linear foot). This means that the investment required by a subsurface pipeline is about five times greater than for a surface canal, and consequently becomes a major consideration to those farmers contemplating a change. Apparently, this large difference in investment is outweighed by the long-run advantages derived from the use of the subsurface pipeline. A noted advantage, among others, is that land formerly occupied by the surface canal can be used for additional production.

Apart from the difference in the level of investment, the self-supplied farmer must take into consideration the annual total costs

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[13]Joseph W. Freeland, An Analysis of the Surface Canal Versus Subsurface Pipeline Irrigation, Southwest Louisiana Rice Area, Unpublished Master's Thesis, Louisiana State University, Baton Rouge, May 1972, p. 1.

[14]Based on (1) 4,061 linear feet of surface canal structure, and (2) 3,510 linear feed of subsurface pipeline structure to a 136.5 acre rice farm. Willard Woolf and Joseph W. Freeland, op. cit., p. 7.

likely to be incurred by both systems once the investment is initially made. Based on a rice farm of 136.5 acres and water obtained from a deep-well source of water, the average annual total costs of a fifteen-year surface canal is estimated at $3,826.23 whereas a thirty-five year subsurface pipeline was $3,669.06. This latter figure includes an expected net return of $353.30 which would be realized from land available for production once the subsurface pipeline is established, (Table 45).

In the surface canal, variable costs account for 54.8 percent of average annual total costs, 29.1 percent of which was for energy (natural gas), and 17 percent for maintenance of the canal structure. With fixed costs accounting for 45.2 percent of annual total costs; 24.1 percent was for pump, well, gearhead unit, and 12.0 percent for the power unit. On the whole, the cost (fixed and variable) of the power unit accounts for 44.8 percent of total annual costs incurred by the use of a surface canal.

On the other hand, the subsurface pipeline whose annual total costs were about $157 less than the surface canal (land returned to production excluded) 59.5 percent were fixed costs and the remaining 40.5 percent constituted variable costs. This cost composition was somewhat reversed in the case of the surface canal, the result of which was due primarily to the difference in annual costs associated with the structure of both systems. For example, the fixed costs of the surface canal structure represents 7.6 percent of total fixed costs in comparison to 20.3 percent for the subsurface pipeline. This confirms the

Table 45. Average Annual Total Costs for Fifteen-year Surface Canals and Thirty-five-year Subsurface Pipeline Systems, Deep Well Water Source, Southwest Louisiana Rice Area, 1971

Item	Surface canal		Subsurface pipeline	
	Amount	Percent	Amount	Percent
Acres irrigated annually	136.5		136.5	
Hours of use annually	1,033.7		867.6	
Horsepower utilized	108.0		126.0	
Production period-years	35.0		35.0	
Length of life-years	15.0		35.0	
Average annual fixed costs:				
Pump, well, gearhead unit	$ 921.43	24.1	$ 921.43	25.1
Pump shed	57.18	1.5	57.18	1.6
Power unit	460.71	12.0	460.71	12.5
Structure				
Surface canal	289.13	7.6	---	---
Subsurface pipeline	---	---	745.60	20.3
Subtotal	$1,728.45	45.2	$2,184.92	59.5
Average annual variable costs:				
Pump unit	$ 191.88	5.0	$ 191.88	5.2
Power unit				
Natural gas	1,116.40	29.1	1,093.18	29.8
Oil	39.81	1.0	36.75	1.0
Oil filter	3.29	0.1	3.29	0.1
Fuel filter	5.00	0.1	5.00	0.1
Grease	2.23	0.1	2.23	0.1
Repairs	90.81	2.4	90.81	2.5
Maintenance				
Surface canal structure 1/	648.36	17.0	---	---
Subsurface pipeline structure 1/	---	---	61.00	1.7
Subtotal	$2,097.78	54.8	$1,484.14	40.5
Average annual total costs	$3,826.23	100.0	$3,669.06	100.0
Less net returns from land returned to production	0.00		-353.30 1/	
Average annual total costs	$3,826.23		$3,315.76	
Average annual total costs per rice acre	$ 28.03		$ 24.29	

1/ Included labor and maintenance costs for pumping facilities.

Source: Willard F. Woolf and Joseph W. Freeland, Cost of Surface Canal Versus Subsurface Pipeline Irrigation, Southwest Louisiana Rice Area, Baton Rouge: Louisiana Agricultural Experiment Station, D.A.E. Research Report No. 460, November 1973, p. 24, Table 9.

fact that the latter system requires a higher level of initial capital investment which is counterbalanced by a useful life of 35 years compared to 15 years for the surface canals. Note that costs of repairs to the surface canal structure accounted for about one-third of variable costs of the surface canal, whereas it was zero with the subsurface pipeline, a factor certainly to be considered when labor supply is a major problem. In addition, the subsurface pipeline occupies relatively less productive land area. When returns to such land is deducted from costs, the average annual costs of the subsurface pipeline to irrigate 136.5 acres is about $513 less than the surface canal. Based upon a deep well water source, the initial capital investment of the subsurface pipeline is five times greater than for the surface canal; however, the difference is more than compensated by the longer useful life associated with the pipeline system, and by the returns to land released for production by the subsurface pipeline.

The above analysis indicates that, using a deep-well source of water, the subsurface pipeline having a 35 year life span, was less costly than the surface canal with a 15 year life span. The same conclusion holds true when surface water is used for rice irrigation (Table 46). Assuming that the farmer obtains water directly from the source rather than from an irrigation canal company, it should be noted, however, that by using surface water, the average annual total costs were practically reduced by one-half as compared to each system obtaining water from a deep-well. This reduction in costs, given the choice in any of the two systems, may be difficult to realize in the

Table 46. Average Annual Total Costs for Fifteen-year Surface Canals and Thirty-five-year Subsurface Pipeline Systems, Surface Water Source, Southwest Louisiana Rice Area, 1971

Item	Surface canal		Subsurface pipeline	
	Amount	Percent	Amount	Percent
Acres irrigated annually	136.4		136.5	
Hours of use annually	1,033.7		867.6	
Horsepower utilized	22.0		40.0	
Length of life-years	15.0		35.0	
Production period-years	35.0		35.0	
Average annual fixed costs:				
Pump unit	$ 80.45	4.2	$ 80.45	4.2
Pump shed and V-belts	85.76	4.5	85.76	4.5
Power unit	276.43	14.4	276.43	14.6
Structure				
Surface canal	289.13	15.0	---	---
Subsurface pipeline	---	---	745.60	39.4
Subtotal	$ 731.77	38.1	$1,188.24	62.7
Average annual variable costs:				
Pump unit	$ 60.50	3.2	$ 60.50	3.2
Power unit				
Diesel fuel	250.16	13.0	381.74	20.2
Oil	112.00	5.9	91.00	4.8
Oil filter	16.45	0.9	13.16	0.7
Fuel filter	5.00	0.3	5.00	0.3
Grease	2.23	0.1	2.23	0.1
Repairs	90.81	4.7	90.81	4.8
Maintenance				
Surface canal structure 1/	648.36	33.8	---	---
Subsurface pipeline structure 1/	---	---	61.00	3.2
Subtotal	$1,185.51	61.9	$ 705.44	37.3
Average annual total costs	$1,917.28	100.0	$1,893.68	100.0
Less net returns to land returned to production	0.00		-353.30	
Average annual total costs	$1,917.28		$1,540.38	
Average annual total costs per acre of rice	$ 14.05		$ 11.28	

1/ Included labor and maintenance costs for the pumping facility.

Source: Willard F. Woolf and Joseph W. Freeland, Cost of Surface Canal Versus Subsurface Pipeline Irrigation, Southwest Louisiana Rice Area, Baton Rouge: Louisiana Agricultural Experiment Station, D.A.E. Research Report No. 460, November 1973, p. 23, Table 18.

southwest region due to the fact that cost increases will result from having to bore wells of greater depth and the concomitantly greater pumping costs to obtain additional water supplies.

An important distinction between the two systems of irrigation, is the degree of water loss. Normally, with a surface canal, additional costs are incurred for damages resulting from muskrat, nutria and cattle, as well as seepage through canal levees and evaporation. In addition, more labor is required for walking and maintenance of levees. These factors, do not usually occur with the subsurface pipeline and are some of the fundamental reasons for the current trend of changing from use of surface canals although they can be established at a considerably smaller level of investment. The loss of water by a surface canal which ranges from 17.5 percent[15] of total water pumped in an individual system to 35 percent[16] for water obtained from a large commercial irrigation company. Other benefits of the subsurface pipeline include: lower maintenance costs, reduction in pumping costs, reclamation of lands, better water management and , more importantly, a future investment which is recoverable.[17]

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[15]Ibid., p. 46

[16]Paul H. Jones, E. L. Hendricks, and Burge Ireland, Water Resources of Southwestern Louisiana, (Washington: U. S. Geological Survey Water Supply), Paper No. 1364, U. S. Government Printing Office, 1956, p. 47.

[17]William A. Hadden, Larkin B. Agnes, and C. E. Slack, Underground Pipelines for Rice Irrigation on Louisiana Farms, (Baton Rouge: Louisiana State University), Cooperative Extension Publication #1594, 1970, p. 2.

In summary, based on this comparative cost analysis, a farmer faced with the decision to invest in an irrigation system, or to change from an already established surface canal must consider his planning horizon. In the long-run he may prefer a subsurface pipeline utilizing surface water as a source of supply, due to the lower annual total costs, both implicit and explicit, associated with such a system over a period of 35 years. This conclusion holds equally well for ground water which is used more predominatly in southwest Louisiana rice areas. Faced with no alternative other than to invest in a surface canal, the farmer's preference will undoubtedly lean to use of a surface source of water supply. It should be borne in mind, however, that apart from cost considerations, the decision to invest in either systems will be conditioned by access to capital, the expected returns from the system, and the extent of cost-sharing in fixed capital investments by the Agricultural Stabilization and Conservation Service (ASCS).[18]

Based on cost data in Table 45, Woolf and Freeland estimated the average annual costs per acre of rice irrigated by surface canal were \$28.03 and by the subsurface pipeline at \$24.29, with both systems using ground water. When using surface water, however, the costs per acre of rice were \$14.05 and \$11.28, respectively as shown in Table 46. Based on the coefficient of 1.02 million gallons of water used per acre

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[18]The maximum cost-share is 50 percent of the cost of permanently located pipelines and fittings, providing such costs do not exceed \$1.50 per linear foot of pipe or pipeline installed. See William H. Hadden, Larkin B. Agnew, and C. E. Slack, _op_. _cit_., p. 5.

(see Table 44), the corresponding costs of water per acre-foot and costs per 1,000 gallons of water are shown in Table 47.

Table 47. Water Costs Per Acre of Rice by Source of Water and Method of Irrigation in Louisiana, 1973 1/

Methods of irrigation	Costs of water per acre-foot		Cost per 1,000 gallons	
	Surface water	Ground water	Surface water	Ground water
	Dollars			
Surface canal	4.50	8.90	0.014	0.028
Subsurface pipeline	3.61	7.77	0.011	0.024

1/ Based on 326,700 gallons per acre-foot.

It is relevant now to turn to the pricing of irrigation water. In comparison to water used for residential purposes, the price of agricultural water is less well-defined. In Louisiana, the price of residential water provided by utilities is regulated by government and most water utility rate schedules are based on a system of declining block rates.

In agriculture, declining block rates do not exist. Where water companies provide water, the charge is on the basis of crop-sharing. This method is more convenient than economic in many respects and may be well above a competitively determined price which, in the long-run, and in a competitive situation, is equal to the average cost of production.

In Louisiana, 64.1 percent of the water used in irrigation in 1967 was self-supplied and as a result a market determined price would be equal to the cost of obtaining the water. Corty claims "that from 60 to 75 percent of the rice farms (in Southwest Louisiana) have private wells or drainage ditches from which they obtain their own water supplies."[19] In view of this, the costs derived above can be construed as an internal price which a self-supplied farmer has to pay for irrigation water.

The supply of water by water companies accounted for 35.6 percent of total agricultural water used in the state in 1967. Where navigable waters are used as a source of supply, that water is free and water companies legally are not entitled to charge for such water.[20] However, as irrigation companies obviously charge for use of water, it would seem that either the statute has been abrogated as to this provision, or the companies are charging only for their services, and not for water.[21]

The pricing of irrigation water is further complicated by the fact that water companies in Louisiana contract for a fixed portion of the physical crop or its market value. This method amounts to either a flat charge irrespective of the amount of water used, or variable depending upon the variations in yield and prices per unit of output. This price may also be tied to the leasing of land upon which the

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[19] Floyd L. Corty, _op_. _cit_., p. 10.

[20] Mark E. Borton and Harold H. Ellis, _Some Legal Aspects of Water Use in Louisiana_, (Baton Rouge: Louisiana Agricultural Experiment Station in Cooperation with U. S. Department of Agriculture), Bulletin No. 537, 1960, p. 82.

[21] _Ibid_.

contracted water is used. This makes price determination complex and difficult since negotiation of an equitable lease becomes a critical factor in determining water charges by irrigation companies. Apparently the price charged will depend on the bargaining strength of the tenant since the company inherently is in an advantageous position by its ownership of land and control of irrigation water. It is because of this imperfection in the market or complications in water pricing that Corty outlined requirements for an equitable lease, which basically rests upon the principle that returns should be allocated between the tenant and landlord according to the proportion of inputs contributed by each party.[22] Needless to say, such a determination is difficult to delineate due to the complementary nature of the inputs in agricultural production.

In Louisiana, farmers obtaining water from irrigation companies usually are charged a 20 percent share of the rice crop for the water. Corty estimated this share in 1967 to range from approximately \$15.00 to \$42.00 per acre, depending upon rice yields.[23] On the assumption of water used per rice acre of 1.02 million gallons, this estimate is equivalent to a range of \$4.80 to \$13.45 per acre-foot of water. The price to a farmer using a surface canal based on estimates on Table 47 ranges from \$4.50 per acre-foot for water obtained from a surface

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[22] Floyd L. Corty, _op. cit._, p. 16.

[23] _Ibid_. p. 11.

source to $8.90 per acre-foot from a ground water source. On the other hand, if the farmer uses a subsurface pipeline, the price ranges from $3.61 to $7.77 per acre-foot from both water sources, respectively. Therefore, regardless of the water system used or sources of supply, the price charged by irrigation companies is greater than if the farmer is able to provide his own water supplies.

Apart from water companies, police juries in the different parishes of the state are legally empowered to incur debt and issue negotiable bonds for the construction of irrigation works and creation of irrigation districts.[24] The Louisiana Constitution limits the amount of the debt to 10 percent of the assessed value of all taxable property within the district. This does not include a 40 year acreage tax or forced contribution not exceeding 50 cents per acre, which would be used to support a bond issue.[25] On the face of it, these charges appear somewhat inequitable since both users and nonusers are required to pay for water supplied for the direct benefit of a specific group of residents.

The Irrigation Districts can also acquire water supplied from another source such as another irrigation system, and impose a uniform charge for its distribution.[26] This charge is separate from the tax imposed for bonds issued. In light of these circumstances, water supplied by irrigation districts is generally provided at a very

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[24] Mark E. Borton and Harold H. Ellis, *op. cit.*, p. 84, footnote.

[25] *Ibid.*

[26] *Ibid.*, p. 85.

nominal cost.

The foregoing analysis indicates that the pricing of water for agricultural use in Louisiana is complicated primarily by nonmarket elements or imperfections which enter into price determination. Based on these elements, it appears that the price charged is relatively low, with the possible exception of the charges by irrigation companies for rice production. This pricing policy may be difficult to support in the future due to the depletion of ground water supplies, salt water intrusion, competition from other water uses, specifically industry, and increased cost of irrigation equipment and possibly higher land costs, especially in the southwestern region of Louisiana.

CHAPTER VII

THE PRICING OF WATER FOR INDUSTRIAL USE IN LOUISIANA

Industrialization and Water Use

Water resources have played an important role in the rapid industrialization of Louisiana, not only as a component of industrial production, but as a primary determinant in the location of manufacturing plants, specifically along the banks of the Mississippi River. The establishment of these plants has been the major factor in the shifts of economic activity from rural to urban areas and from one region of the state to another. As a matter of fact changes in the geographic distribution of manufacturing activities between 1929-1972 and projected changes to the year 2000 correspond to aggregate changes in total economic activity in the state. These activities are associated with the manufacture of products directly or indirectly related to food, petroleum, chemical, metal, and lumber industries (Table 48).

In 1972 manufacturing enterprises generally characterized as voluminous water users totaled 3,639 plants. In that year also, 40 new plants were established at a cost of \$1.1 billion of which about one billion dollars were invested in electric power and the remainder primarily in petroleum and chemical plants. Actually, 1972 is regarded a record year for Louisiana's industrial development for in addition to the 40 new plants which were established, another 238 expanded their existing operations. Louisiana now ranks fourteenth in the nation in terms of the rate of new industrial investment and the present outlook indicates that such a ranking may continue to improve.[1]

This expansion of industrial activity holds great significance for the use and consumption pattern of water resources. Such activities led the Public Affairs Research Council to state that Louisiana "has an amount of water for industrial use unequalled by any other state in the nation . . . (and) ranks in first place in the nation with respect to fresh water for industrial use."[2] A liberal water supply has been suggested as a fundamental reason for plant location in the state. Where liberal supplies of water are available, plants need not install costly water-cooling equipment. However, the liberal supplies are gradually being depleted and ground water levels in industrial areas, for example, in Baton Rouge, have declined to a critical level and at the same time surface sources are continually being polluted. This deteriorating situation naturally contributes to increased costs of water for industrial uses.

Table 48 shows the value added by manufacturing industries, the total water intake and the value added per billion gallons of water

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[1] Louisiana Horizons, (Baton Rouge: Louisiana Department of Commerce), 1973, p. 8.

[2] Factors Affecting Louisiana Industrial Development, (Baton Rouge: Public Affairs Research Council of Louisiana), November 1962, p. 1.

Table 48. Total Water Intake, and Value Added Per Billion Gallons of Water Intake by Groups of Industries in Louisiana, 1968

Industry	Value added	Total intake	Value added 1/
	Million dollars	Billion gallons	Million dollars/ billion gallons
Food and kindred products	211.9	55.2	3.8
Lumber and wood products	14.4	1.1	13.1
Paper and allied products	198.6	82.5	2.4
Chemical and allied products	666.3	497.6	1.3
Petroleum and coal products	256.2	247.2	1.0
Stone, clay, and glass	39.5	2.1	18.8
Fabricated metal products	42.2	.3	140.6
Total	1,686.6	1,039.0	1.6

1/ Calculated.

Source: U. S. Bureau of the Census, Census of Manufactures, 1967: Subject Statistics: Water Use in Manufacturing, Washington, D. C.: U. S. Government Printing Office, 1971, pp. 7-95, Table 2.

intake in 1968 in Louisiana. The major water users are the chemical and fuel industries, accounting for a combined total of approximately 73 percent of industrial water intake. The value added by these two industries, however, represents only 55 percent of the total value added by all industries, a significant consideration in the planning of industrial development and water use in Louisiana. Of more meaningful significance is the value added per billion gallons of water intake and, as the table indicates, these two industries have the lowest coefficient in relation to the others.

Examining further the low coefficient of value added per billion gallons of water intake in these two industries, one may argue from a water conservation standpoint, that industries with higher coefficients should be attracted or established in Louisiana. This argument, however, is rather weak, since about 90 percent of industrial water intake is discharged, i.e., not consumed in the manufacturing process.[3] The concern arises from the fact that the discharged water may need some treatment before its next use and, moreover the concentration of water using plants contribute to the decline of the water table in a given water region.

Supply and Demand
Characteristics of Industrial Water Use

The demand for water for industrial use depends, largely upon the type of industries located in a given area of activity and their rate of output. Table 49 shows some of the major water using industries and water requirements per unit of output of each industry.

[3] Water in Industry, (New York: National Association of Manufacturers, 1965), p. 10.

Although difficult to compare since the unit of output of each industry is different, it is still possible to state that in an area characterized by concentration of petroleum, paper, and aluminium industries, the demand for water will be very great. The water intake by these industries to produce 100 barrels of crude oil requires 77,000 gallons of water. This is equivalent to supplying eight families with domestic water for one month.

Table 49. Industrial Water Requirements of Selected Industries

Industry	Water requirements
Electricity	80 gallons per kilowatt of electricity
Petroleum:	
Gasoline	7 - 10 gallons per gallon of gasoline
Oil refinery	77,000 gallons per 100 barrels of crude oil
Pulp and Paper Mills:	50,000 - 150,000 gallons per ton of pulp
Inking paper	38,000 gallons per ton of paper
Paper board	14,000 gallons per ton of paper board
Straw board	26,000 gallons per ton of straw board
Aluminium	1,920,000 gallons per ton of aluminium
Cement	750 gallons per ton of cement
Refined cane sugar	1,000 gallons per ton of sugar

Source: Manual on Industrial Water and Industrial Waste Water, Philadelphia: The American Society for Testing and Materials, Technical Bulletin No. 148-H, 1965, pp. 918-919.

Water for industrial use comes from both surface and ground sources, with the former being the predominant source in Louisiana. Surface water is generally less costly, especially since water for industrial use need not meet the same quality standards required for domestic use. Table 50 shows that of all the surface water used by industry, about 79 percent comes from the Mississippi River, (about 300 billion gallons in 1967) along whose banks in the southern half of Louisiana the major manufacturing industries are located.

Table 50. Major Surface Sources and Intake of Water by Industries in Louisiana, 1967

Stream	Annual intake	Percent
	Thousand gallons	
Bayou Bartholomew	8,806,518	2.3
Bayou Bodcau	12,194,000	3.2
Bayou Cocodrie	12,648,960	3.3
Bayou Lafourche	14,195,655	3.7
Bayou Terrebonne	3,210,292	0.8
Bayou Teche	6,564,536	1.7
Bogalusa Creek	4,148,000	1.1
Intracoastal Waterway	11,950,660	3.1
Mississippi River	300,464,913	78.7
Ouachita River	5,620,404	1.5

Source: Gulf South Research Institute, Present Industrial Water Use in Louisiana, Baton Rouge: Department of Public Works, Series 1, Volume III, June 1970, p. 50.

In Table 51, a comparison of both ground and surface water pumped per day for industrial use in selected parishes of Louisiana is shown for the years 1965 and 1970. In the span of five years total pumpage (both sources combined) increased by 58.2 percent. The increased significance of surface water for industrial use is verified by the fact that in 1970 it accounted for 88 percent of total pumpage in comparison to 85.2 percent in 1965. This is further confirmed in that pumpage of surface water was about six times as great as ground water in 1965, whereas in 1970 it was about seven and a half times greater.

Table 51. Pumpage of Water in Selected Parishes for Industrial Use in Louisiana, 1965 and 1970 1/

Parish	1965		1970	
	Ground	Surface	Ground	Surface
	- - - - - Million gallons per day - - - - -			
Ascension	2.79	12.23	3.35	108.53
Calcasieu	71.24	620.00	120.28	642.09
East Baton Rouge	59.99	339.96	99.59	361.53
Iberville	7.59	278.42	11.49	525.11
St. Bernard	2.72	502.90	1.63	590.59
St. Charles	19.29	196.61	14.07	837.46
St. James	7.83	8.08	5.36	220.00
All others	216.02	277.83	240.23	371.69
Total by source	387.47	2,236.03	496.00	3,657.00
Total	2,623.50		4,153.00	
Percent of total 2/	14.8	85.2	12.0	88.0

1/ Does not include thermoelectric use.

2/ Calculated.

Source: Data for 1965 were taken from P. P. Bieber and M. J. Forbes, Jr., Pumpage of Water in Louisiana, 1965, Baton Rouge: U. S. Geological Survey, 1966, p. 6. Data for 1970 were taken from Don C. Dial, Pumpage of Water in Louisiana, 1970, Baton Rouge: U. S. Geological Survey, 1970, pp. 8-9.

With the continued establishment of new manufacturing plants and the expansion of current ones, there will be a considerable increase in the use of water by manufacturing industries. According to one report, industrial use should reach 7,968 million gallons per day (mgd) by 1980, and 19,643 mgd by year 2000, with 89 percent of the latter amount being derived from surface sources.[4]

A significant aspect of industrial water use, is the difference between the amount of water intake and the quantity of water discharged, i. e., the actual amount of water consumed in the manufacturing process. Table 52 shows the total intake, total discharge, and gross water used by the major groups of manufacturing industries in Louisiana during 1968.

From Table 52 it is seen that fabricated metal products had no consumptive use (total intake minus total discharge) of water. The chemical and fuel industries, the most significant industries in Louisiana, discharge an average of 96 percent of water intake. These industries also have the lowest dollar value added per billion gallons of intake, yet they contribute significantly to income generation and employment. Their only weakness, as to water use, is their ability to create water pollution, an element which is already being surmounted by the installation of treatment plants to improve quality of discharged water. The direct costs of water treatment plants are normally internalized by the respective firms.

A characteristic feature of industrial water use in Louisiana is that most of the major manufacturing plants supply their own water. Of

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[4]Gulf South Research Institute, Present and Projected Water Requirements for Louisiana, 1970-2020, op. cit., p. 12.

Table 52. Total Intake, Gross Water Used and Total Water Discharged, by Manufacturing Industries in Louisiana, 1968

Industry	Total water intake	Gross water used 1/	Total water discharged	Discharge as percent of intake 2/
	------ Billion gallons		-------	Percent
Food and kindred products	55.2	63.2	52.8	95.7
Lumber and wood products	1.1	1.5	.7	63.6
Paper and allied products	82.5	179.1	76.3	92.5
Chemical and allied products	497.6	147.6	473.2	95.1
Petroleum and coal products	247.2	713.5	240.9	97.5
Stone, clay, and glass products	2.1	5.1	1.5	71.4
Fabricated metal products	.3	.4	.3	100.0
Total	1,039.9	2,279.1	999.2	96.1

1/ Gross water used represents the estimated quantity of water that would have been required if no water had been recirculated or reused.

2/ Calculated.

Source: U. S. Bureau of the Census, Census of Manufactures, 1967: Subject Statistics: Water Use in Manufacturing, Washington, D. C.: U. S. Government Printing Office, 1971, Section 7, p. 95, Table 2.

a total intake of 1,040 billion gallons in 1968, 1,030 billion gallons were provided by the companies own water systems, while the remaining 10 billion gallons were obtained from other water utility systems.[5] This situation is explained by the fact that water utilities generally are not designed to serve the large volume demands of industrial users. In addition, if utilities had the designated capacity to serve these industries, the water utility costs per 1,000 gallons would most likely be greater than those of a self-contained system.

Total water costs are partially influenced by the degree and number of treatments performed prior to its use. Table 53 indicates that 13.2 percent of total water intake for industries was treated before use by Louisiana manufacturing industries during 1968. However, on the individual industry level, wide variations occur depending upon the nature of industry output. Chemical and allied products, which are the major water users in Louisiana, treat only 7.6 percent of its water intake whereas paper products treat 61.5 percent. In addition, of the 182 manufacturing establishments in 1968, 71 performed no treatment. However, of the amount that performed treatment the greater number (41) was in the category of chemical and allied products. The most common treatment among all industries was coagulation, (76.4 billion gallons of water) followed by filtration, corrosion control, and

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[5] U. S. Bureau of the Census, Census of Manufactures, 1967: Subject Statistics: Water Use in Manufacturing, (Washington, D. C.: U. S. Government Printing Office), 1971, Section 7, p. 95, Table 2.

Table 53. Water Intake, Water Treated Prior to Use, and Number of Manufacturing Establishments in Louisiana, 1968

Industry	Total intake	Total treated prior to use	Treatment as percent of intake 1/	Establishments	
				Treatment	No treatment
	- - - - Billion gallons - - - -			- - - - Number - - - -	
Food and kindred products	55.2	4.3	7.9	30	32
Lumber and wood products	1.1	.2	18.2	5	5
Paper and allied products	82.5	50.0	61.5	13	3
Chemical and allied products	497.6	37.6	7.6	41	14
Petroleum and coal products	247.2	43.5	17.6	16	2
Stone, clay, and glass products	2.1	0	0	4	6
Fabricated metal products	.3	0	0	0	0
Total	1,039.9	136.9	13.2	111	71

1/ Calculated.

Source: U. S. Bureau of the Census, Census of Manufactures 1967: Subject Statistics: Water Use in Manufacturing, Washington, D. C.: U. S. Government Printing Office, 1971, Section 7, p. 122, Table 6.

softening treatments.[6]

In Louisiana, water used in manufacturing is devoted primarily to cooling, processing, boiler-feed, and sanitary purposes. In 1967 cooling accounted for 69 percent of total water intake while processing accounted for 17 percent.[7] In the respective manufacturing industries, paper products and chemical products use about 90 percent of their water intake for cooling and processing, while the fuel industry uses about 77 percent for that purpose. Water used for these two purposes also results in a high discharge rate and a relatively low consumptive use of water in these industries as discussed above.

So far the analysis of industrial water use has been centered on the state as a whole. Since industries are not uniformaly distributed across the state, it may be useful to examine briefly the industrial water demands among the six Water Resource Planning Areas (WRPA). On this basis, industries in the three southern regions accounted for 90 percent of the industrial water intake in 1967, with about 37 percent of this amount used by industries in south central WRPA (Table 54).

Industries in the south central, and southeast WRPA, as one report indicates, relied primarily on self-supplied surface water obtained

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[6]U. S. Bureau of the Census, Census of Manufactures, 1967: Subject Statistics: Water Use in Manufacturing, op. cit., p. 122.

[7]Gulf South Research Institute, Present Industrial Water Use in Louisiana, (Baton Rouge: Department of Public Works), Series I, Volume III, June 1970, p. 22, Table 5.

Table 54. Industrial Water Intake by Water Resource Planning Areas (WRPA) in Louisiana, 1967

Industry	Northwest	North central	Northeast	Southwest	South central	Southeast	Total
	- - - - - - - - - -	- - - - - - -	Million gallons	- - - - - - -	- - - - - - -	- - - - - - -	
Food and kindred products	1,237	1,654	54	9,116	4,665	43,828	60,555
Textile mill products	0	0	0	0	0	17	17
Lumber and wood products (except furniture)	9,592	15,200	4,170	3,838	5,851	1,376	40,027
Paper and allied products	375	10,181	144	4,700	3,379	7,388	26,167
Chemicals and allied products	11,654	27,750	1,899	81,647	271,976	115,962	510,888
Petroleum refining and related industries	11,916	911	12	90,013	77,621	36,531	217,004
Stone, clay, glass, and concrete products	165	279	46	941	1,172	3,593	6,196
Primary metal industries	712	0	0	0	1,348	126,664	128,724
Other	1,247	281	2	239	330	1,159	3,258
Total	36,898	56,256	6,327	190,494	366,342	336,518	992,836
Regional percentages 1/	3.7	5.7	.6	19.2	36.9	33.9	100.0

1/ Calculated.

Source: Gulf South Research Institute, Present Industrial Water Use in Louisiana, Baton Rouge: Department of Public Works, Series I, Volume III, June 1970, p. 22, Table 5.

mainly from the Mississippi River, while the southwest WRPA, depends on water from ground sources.[8] In the three northern regions, industries used both ground and surface water sources on about an equal basis. However, in the north central WRPA industries generally purchased a greater proportion of their water supplies from water utilities.

Costs and Pricing of Water for Industrial Use

The study of water costs and pricing for industries is generally difficult due to the lack of information and the nature of the industrial process. Bramer states:

> In the case of industrial water utilization, little cost information is available, and standardized procedures for the acquisition of such information have not been developed. Few professional engineers (and economists) are concerned with this subject, and little information is exchanged, except for costs of water treatment equipment and chemicals and in the area of pollution control. Costs are not ordinarily revealed outside of a firm, even those of such a universally used material as water. In many, probably most cases, industrial plants do not really know the costs of water utilization.[9]

This situation is in no way different in Louisiana where practically no response was obtained from industries located in the state. Company officials generally regard such information as of a "sensitive" nature.

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[8] Ibid., p. 16.

[9] Henry C. Bramer, "The Value of Water in Industry," Water - 1969: Chemical Engineering Progress Symposium Series, (New York: American Institute of Chemical Engineers), Volume 65, No. 97, 1969, p. 281.

Apart from this, costs of water are generally considered a rather insignificant amount of total plant output costs. These costs are affected by technological changes, product output, quality requirements, quality of raw product input, and some lesser factors. The operating rate of the plant is important since higher rates of operation means the amount of water intake per unit and water discharge per unit are lower. Therefore, the average cost of water per unit of production should decrease as operating rates increase and as optimum output is realized.

An estimation of industrial water costs is quite difficult since water for industrial use is often regarded as a catalyst in the manufacturing process, and the major manufacturing plants are self-supplied and are characterized by a high rate of discharge ranging between 90-100 percent of their total water intake. Added to this is the fact that the major water-using industries in the state do not confine the production to a primary product but to a host of subsidiary by-products, all of which have a claim on water use.

The difficulty in assessing water costs to industry is not to imply that the amount of water used in the manufacturing process is not affected by the costs. High costs tend to place restraints on water use. Although surface water in Louisiana is relatively abundant, water costs relate to capital investment for pumping and holding facilities. However, once the initial investment is made in these capital facilities, water costs are related only to the maintenance and operation of these facilities.

Industrial water costs have been increasing over the last decade, not because of increases in total water intake, but for capital investment in devices to minimize water pollution. Pollution standards may force plants to reduce discharges, thus encouraging increased recirculation or reuse of a given volume of water intake, and this will tend to reduce the volume of water intake.

Although investments in pollution control devices have already increased the costs of industrial water utilization, these costs still represent a small fraction of total plant output costs. Gurnham, who studied the chemical manufacturing industry for several years estimated annual expenditures for water pollution control at about 0.33 percent of net plant and equipment investment expenditures.[10] Further, Bower claimed that costs of water pollution control in the chemical industry as well as other heavy water-using industries are generally several times greater than intake water costs, the ratio ranging from 3:1 to 6:1.[11] Based on these estimates, it was calculated that the total costs of industrial water, as a proportion of total production costs of a manufacturing firm, would possibly range from about 0.2 percent to approximately 3.0 percent, i.e., an average of 1.6 percent.[12]

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[10] C. F. Gurnham, "Control of Water Pollution," Chemical Engineering, Volume 20, No. 12, December 1963, p. 204.

[11] Blair T. Bower, "Economics of Industrial Water Utilization," in Water Research, Allan Kneese and Stephen C. Smith, (Eds.), (Baltimore: The Johns Hopkins Press), 1966, p. 150.

[12] Ibid.

An important element in industrial water use is the role and impact of technology on water use. Technological changes in manufacturing are primarily centered on the reduction of recirculation costs. Apart from this, the level of such costs are affected by: (1) the complexity and number of component processes in production, (2) the spatial layout of the production process, (3) the number of products produced, and (4) the extent of water quality degradation in the production process.

From the analysis of the supply and demand characteristics examined earlier, the major component of total industrial water intake costs in Louisiana, will be expenditures made for energy consumption, mainly electricity for pumping purposes once capital facilities have been established. Since most industries are self-supplied and located in close proximity to the sources of water, transmission costs will be insignificant. Costs of water treatment can be considered in similar context, due to the fact that the major water-using industries in the state perform a minimum of treatment on water intake.

Capital investment costs in providing water for industrial use in Louisiana will be primarily centered on the purchase of the pumping unit, the price of which will depend upon the rate of water flow required by the specific manufacturing enterprise. In the petroleum industry, the most common pumping units have a capacity of 400-450 horsepower or a flow of 2,000 gallons per minute. Cost of this pump is estimated at $20,000. Therefore, the total cost associated with the supply of industrial water will be dependent to a large extent on the number of pumps required and the costs of maintenance and operation.

Based upon a very limited sample of chemical companies, the total cost for 10,184.1 million gallons of self-supplied surface water in 1971 amounted to $861,308 of which variable costs accounted for $524,015 (61 percent) and fixed costs $337,239 (39 percent). On this basis, the total cost of water amounted to $0.08 per 1,000 gallons ($0.05 constituting variable costs, and $0.03 fixed costs). In the aluminum industry, official estimates of water costs range between $0.17 to $0.19 per 1,000 gallons.[13] These figures are considerably higher than costs of water for use in agriculture which approximates $0.03 to $0.14 per 1,000 gallons.[14] For residential water provided by the largest and most efficient utility in the state, the average cost is $0.30 per 1,000 gallons. This may explain partially why most manufacturing industries do not purchase water from an outside agency but provide their own water supplies.

Although, the chemical plants may not be representative, one may wish to examine their costs of $0.08 per 1,000 gallons with costs of industrial water use in other states. Bramer who studied 22 industrial plants in 13 states, estimated costs as shown in Table 55.[15]

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[13]Personal letter from the Supervisor of a Large Metal Industry.

[14]Based on costs of using a surface canal and free surface water source.

[15]Henry C. Bramer, _op. cit._, pp. 281-287.

Table 55. Costs of Industrial Water in Selected Industries in the United States, 1969

Industry	Principal source	Use	State	Per 1,000 gallons intake
				Dollars
Power	Surface	73 gallons per kilowatt hour	Maryland	0.009
Power	Surface	14 gallons per kilowatt hour	New Jersey	0.011
Power	Ground	68 gallons per kilowatt hour	Delaware	0.013
Paper	Ground	84,836 gallons per ton	Ohio	0.106
Steel	Surface	52,202 gallons per ton	Pennsylvania	0.016
Power	Surface	33 gallons per kilowatt hour	West Virginia	0.018
Steel	Surface	32,787 gallons per ton	New Jersey	0.019
Steel	Surface	62,329 gallons per ton	Indiana	0.029
Paper	Surface	84,390 gallons per ton	Minnesota	0.033
Steel	Surface	16,334 gallons per ton	Pennsylvania	0.084
Steel	Surface	35,353 gallons per ton	Pennsylvania	0.077
Steel	Surface	54,096 gallons per ton	Pennsylvania	0.056
Paper	Ground	20,710 gallons per ton	Indiana	0.113
Paper	Surface	21,467 gallons per ton	Vermont	0.132
Steel	Ground	9,111 gallons per ton	Pennsylvania	0.151
Steel	Ground	8,030 gallons per ton	Pennsylvania	0.191
Petroleum	Surface	2,499 gallons per barrel	Pennsylvania	1.60
Paper	Surface	301,818 gallons per ton	North Carolina	0.215
Steel	Purchased	42,927 gallons per ton	Pennsylvania	0.352
Petroleum	Surface	1,670 gallons per barrel	Texas	2.64
Petroleum	Brackish	1,287 gallons per barrel	Texas	7.00
Steel	Purchased	1,250 gallons per ton	Ohio	0.455

Source: Henry C. Bramer, "The Value of Water in Industry," Water - 1969: Chemical Engineering Progress Symposium Series, New York: American Institute of Chemical Engineers, Volume 65, No. 97, 1969, p. 284.

Costs per 1,000 gallons of water ranged from a low of \$0.009 for a power plant in Maryland to a high of \$7.00 for a petroleum plant in Texas. However, 17 of these 22 plants incurred a cost ranging from \$0.01 to \$0.21 per 1,000 gallons of water. Further more, half of all the plants incurred a cost of \$0.10 or less per 1,000 gallons. Therefore, the cost of \$0.08 per 1,000 gallons of water reported for chemical plants seems to represent an average charge generally associated with industrial water use.

To further verify this statement, one can examine the cost of surface water to the respective plants in Bramer's study.[16] Table 55 shows there were 14 plants using surface water whose costs ranged from a low of \$0.009 to \$2.64 per 1,000 gallons of water. However, within this range water costs for 11 plants were \$0.13 or less per 1,000 gallons of water (i. e., 50 percent of 22 plants). Therefore, the costs of \$0.08 per 1,000 gallons of water appears to be a reasonable cost estimate for industrial water use in the 13 states studied by Bramer. It may also be an acceptable estimate for Louisiana industries as well. As shown in Table 56, of the four industries studied by Bramer, the costs for steel was \$0.041 per 1,000 gallons, paper \$0.079, power \$0.013, and petroleum \$2.43. Peters and Timmerhaus estimated the costs of industrial water from an underground source at

[16] _Ibid._

$0.03-$0.15 per 1,000 gallons and from a surface source at $0.02-$0.06 per 1,000 gallons.[17]

Table 56. Average Industrial Water Usages and Costs, 1969

Parameter	Steel	Paper	Power	Petroleum
Cost per 1,000 gallons intake	$0.041	$0.079	$0.013	$2.43
Cost as percent of income	0.56	1.54	2.06	5.18
Cost per product unit	$0.950	$5.06	$0.00038	$0.526
Direct cost breakdown:				
Raw materials (percent)	46.2	17.5	2.7	9.0
Labor (percent)	36.4	32.7	4.8	4.6
Maintenance & power (percent)	17.4	49.8	92.5	86.4
Total cost breakdown:				
Direct costs (percent)	47.6	38.5	71.4	11.1
Indirect costs (percent)	13.1	9.3	2.5	0.4
Fixed costs (percent)	39.3	52.0	26.0	88.5
Average plant use 1,000 gallons per day	70,697	21,859	157,581	335,450

Source: Henry C. Bramer, "The Value of Water in Industry," Water - 1969: Chemical Engineering Progress Symposium Series, New York: American Institute of Chemical Engineers, Volume 65, No. 97, 1969, p. 284.

In Bramer's study, total industrial water costs were divided into three categories: (1) direct costs which included expenditures for raw materials, labor, maintenance, and power; (2) indirect costs were

[17] Max S. Peters and Klaus D. Timmerhaus, Plant Design and Economics for Chemical Engineers, (New York: McGraw-Hill), 1968, p. 772.

for payroll and plant overhead; and (3) fixed costs related to depreciation, property taxes, and insurance. Within the category of direct costs, the major expenditure was for maintenance and power of the water unit (Table 56). Within the three broad cost categories, however, direct costs constituted a major proportion of total costs in the power industry, whereas in the petroleum and paper industries fixed costs were the major component.

In summary, apart from the figures above, an attempt to estimate industrial water utilization costs in Louisiana is complex and difficult since one must take into consideration the rate of industrialization, the location of plants, the nature and diversity of the manufactured products, and the availability of water supplies. The supply and demand characteristics indicated that the major water using industries in the state are those associated with the manufacture of chemical products and fuel (petroleum) products. These industries, mostly self-supplied from close-by surface sources, perform very little water treatment before intake for cooling purposes. This accounts for the relatively low price associated with water use as shown by the records of several industrial plants. This low price (or cost) is likely to continue as long as access to liberal water supplies remains fairly easy. However, should competition develop as water scarcity arises, the cost of industrial water use will increase.

Water, although an essential input in the manufacturing processes in Louisiana, constitutes only a small part of total production costs. Water is used mainly for cooling, and controlling pollution seems to be of greater concern than obtaining supplies in Louisiana. Since costs of obtaining water, and consequently its price, are negligible, there is very little control of its use.

The price mechanism attempts to provide checks and balances in the production and consumption of water as well as all other goods and services. In Louisiana, the price mechanism is established primarily for residential water consumption. In agriculture and industry, prices are equivalent to internal costs as long as government imposes no controls.

In light of this serious concern over ground water supplies, the Louisiana Legislature in 1972 declared in Section 1 of Act No. 535, that "the utilization of ground water resources is . . . declared to be a matter of public interest". Accordingly the Act attempts "to provide for the efficient administration, conservation, and orderly development of ground water resources of the State of Louisiana." To fulfill this purpose, the Act requires registration of all wells producing in excess of 50,000 gallons per day. This provision of the Act appears directed primarily to large volume users of groundwater such as irrigated agriculture and large industries. Although the Act does not imply any specific control of groundwater use, the registration of wells and their capacity will at least give some indication as to need for future planning of groundwater use in Louisiana.

CHAPTER VIII

COST CONSIDERATIONS AND A PROPOSED WATER PRICING POLICY

Average Cost Pricing Versus Marginal Cost Pricing

Cost theory suggests that within a perfect market economy, optimum resource allocation is a function of the interaction between suppliers of goods and services and their consumers. The physical and geographical constraints on resources limit production of goods and services. This phenomenon, in combination with the pricing mechanism of the market, provides a functional set of checks and balances that either dampens or stimulates production and consumption. Economic theory also indicates that "free" resources should be exploited within any production function to a point where any additional increase in output will make the marginal product equal to zero.

It is within this context that water production and consumption has been generally viewed. Water has been considered as an abundant resource and generally a low cost economic good. Emphasis has been on expansion in supply rather than efficient production and distribution among competitive users through the pricing mechanism. However, as scarcity develops, conflicts arise in the production and consumption of water resources. Recognition of these conflicts have resulted in the establishment of water rights laws and public controls in the distribution and use of the resource. These laws and public controls are regarded as major imperfections in the water market impeding the functioning of the price mechanism.

Up to the present time, water pricing policies were based on average cost rather than marginal cost. The aim of an average cost pricing approach, apart from its ease and simplicity of administration, is to provide water supplies at a price sufficient to cover the average costs of production. This may be a sound economic policy, particularly where the firm is incurring decreasing average costs of production. However, as an economic good, the application of an average cost pricing policy to water can lead to overcharging or undercharging in its use with the resulting effect of under-investment or over-investment in water systems and a misallocation of resources.

On the other hand, charging a price based on marginal costs of water production tends to improve resource allocation, since this price would approach or be equal to the cost of the last unit supplied. A comparison of marginal-cost and average-cost pricing and their effects on consumption and production of water is brought out by considering the demand curves D_2 and D_3 in Figure 8. With demand at D_2, based on the principle of marginal cost pricing, consumers would be willing to purchase and suppliers would supply at quantity Q_2 at the equilibrium price of P_{21}. This price, it should be noted, fails to recover the average total costs of production. For the water system to survive economically, the number of customers and consequently demand would have to increase to D_1 and output to Q_1 where the price P_{11} is equal to both average and marginal costs of production or the price must be raised to P_{41}. Apart from this, however, producing the quantity Q_2 and charging the price P_{21}, is efficient from the standpoint of resource allocation since this price reflects what consumers are willing to pay and suppliers to supply the marginal unit of production.

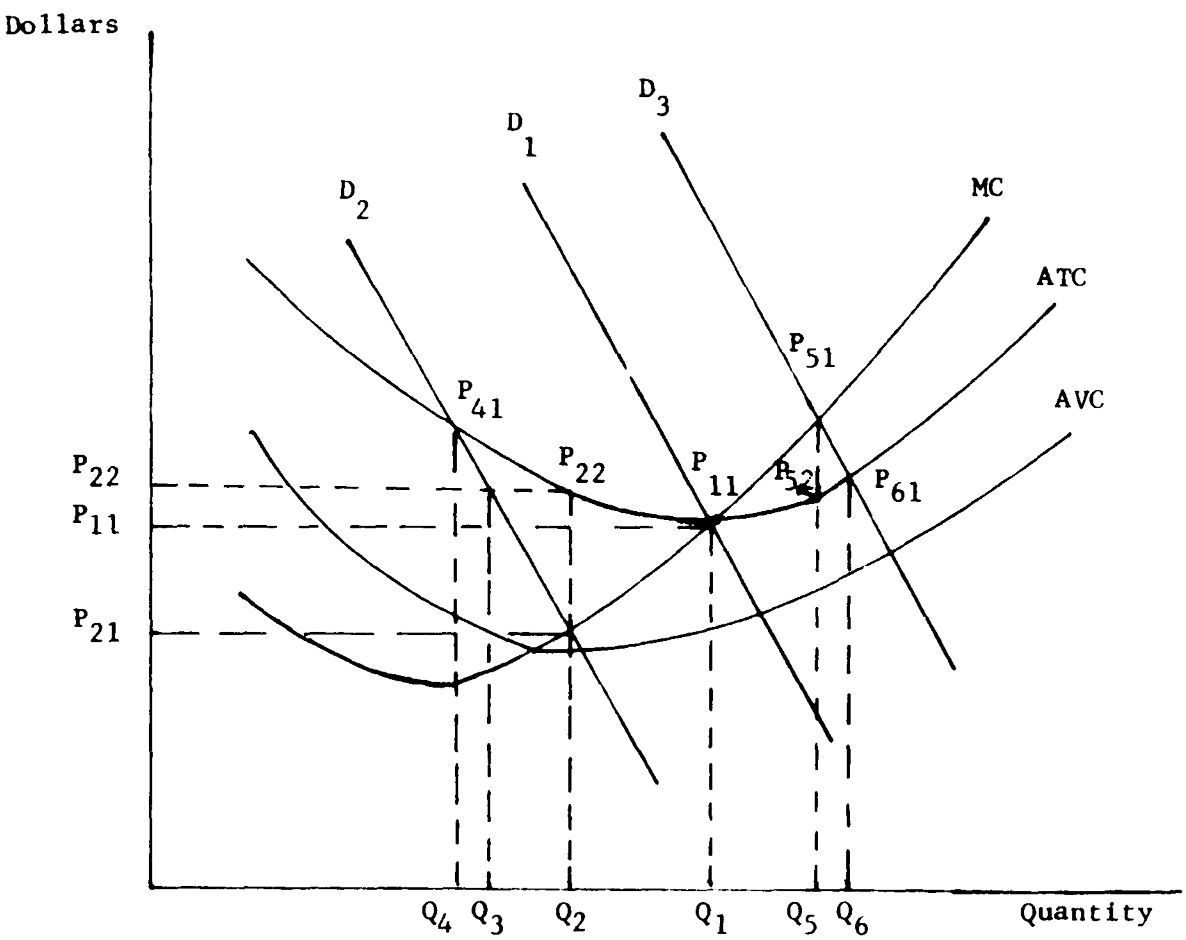

Figure 8. Marginal Cost Pricing and Average Cost Pricing.

Based on average cost pricing, the supply of Q_2 will result in a price of P_{22} which is higher than the price P_{21} which water consumers are willing to pay for this quantity of water. A price equivalent to P_{22} would, therefore, reduce consumption to Q_3 which is less than Q_2. However, if this price is charged, the water supplying firm will fail to recover the cost of production. To achieve this, price will have to increase to P_{41} and consumption and production further curtailed to Q_4. Therefore, based on average cost pricing, given the demand curve D_2, consumers will have to pay a higher price and consequently reduce their consumption well below the amount possible under the principle of marginal cost pricing.

A somewhat opposite situation occurs if a water supplying firm faces a consumer demand curve as D_3. Consumers are willing to purchase the quantity Q_5 at a price P_{51} which is equal to the marginal costs of supplying this quantity of water. This price not only recovers the cost of production, but generates a revenue surplus since marginal cost is greater than average cost. Based on average cost pricing, the supply of Q_5 will result in a price P_{52} which is lower than the marginal cost-price of P_{51}. To reflect consumer's demand as shown by D_3 average cost pricing dictates a price of P_{61} and an increase in quantity demanded from Q_5 to Q_6. In other words, average cost pricing has resulted in a larger quantity of water consumed at a lower price. But this level of consumption is not efficient from the standpoint of resource allocation in water production.

Although marginal cost pricing results in the efficient allocation of water resources, its use has been decried by the proponents of average cost pricing since water systems are generally regarded as decreasing cost enterprises. The use of marginal cost pricing under this cost condition will lead to financial deficits consistent with any quantity less than Q_1 (Figure 8). This was one of the reasons, among others, why the general pricing practice, specifically among water utilities, emphasized average cost pricing since this approach will recover the costs of production.

Opponents of average cost pricing, on the other hand, do not reject the concept of decreasing costs, but add that the water systems may also experience increasing costs as well. Decreasing costs, it is claimed, may be realized at the early stages of operation, but as demand for water increases and scarcity of supplies develop, the water system may face increasing average costs of production. Within this stage of increasing average cost, marginal cost pricing will result in some profit to the water system and, in addition, will facilitate an efficient allocation of water resources.

The use of marginal cost pricing has been also criticized as being difficult to implement because of the seasonality of water demand. Seasonality of demand results in a shift of the demand curve and is normally referred to as on-peak and off-peak demands. For example, the demand curve D_2 can be considered as representative of off-peak demand while D_3 can be regarded as on-peak demand. On the basis of marginal cost pricing, faceo with the off-peak demand D_2, the water utility will incur a financial deficit. But with a demand of D_3, a profit is realized, as explained above. Under this situation, proponents of marginal cost pricing advocate that the financial gains realized at on-peak demand D_3, can be used to recover the financial deficit which resulted from off-peak demand at D_2.

It is believed that if the price of water is based on marginal cost of production it would curtail agricultural utilization in favor of industrial utilization. Special preference to agriculture is common and generally the price charged is below average cost. The fact that water has a higher marginal value when used for industrial or domestic uses indicates that the "market" places a higher marginal value in the production of other goods rather than on food and fib .

The Use of Average Cost Pricing in Louisiana

An examination of average cost pricing in contrast to marginal cost pricing shows a tendency to: (1) result in an unrealistic price for the commodity, (2) adversely affect the quantity of water demanded, and (3) create disproportionate investment in water supply facilities.

As reflected by this study, 33 percent of the water utilities providing residential water realized a small net income loss since the price charged for water failed to recover the costs of production. In industry, a market price for water does not exist, where industries develop their own supplies. This is particularly significant in Louisiana where 99 percent of the industries have their own water systems. In agriculture, the price charged by water companies for rice production was estimated at \$4.80 to \$13.45 per acre-foot in 1968 contingent upon rice yield and the market price for rice. This cost to rice farmers is considerably higher than when they obtained their supplies by developing their own wells and water systems.

The common pricing practice of water utilities in Louisiana is to establish a minimum charge for a given volume of water and to this is added declining block rates for increasing volumes of water consumed. The objective of this practice is to charge a price which covers the average cost of water supplied. In other words, this is the average cost pricing approach whose merits and demerits have been discussed.

To determine the extent and use of average cost pricing in Louisiana, water utilities providing residential water service were asked to indicate the major considerations in deriving rate schedules, service charges, fire protection rates, and surcharges for air-conditioning and outside user charges. Similar considerations were not applicable in terms of industrial and agricultural water use, since most industries and most farm units are self-supplied. Many rice farmers obtain water from irrigation canal companies where the price charged constitutes a proportion of the crop as negotiated through contract.

A series of cost considerations or statements on residential water pricing as derived from the survey, are summarized in Table 57. Of the 231 water utilities reporting, all based their rate determination on average costs. Within this group, there are variations of the components used in computing average costs for rate determination. About 75 percent of the water utilities indicated the recovery of total costs,

Table 57. Cost Considerations in Planning Rate Schedules by Water Utilities in Louisiana, 1971

Statements	Cost consideration	Percent of water utilities
Cover total costs	Average cost	75.0
Cover costs plus a return on investment	Average cost	19.0
Cover cost plus a surplus for emergencies	Average cost	1.0
Cover cost plus a reasonable profit	Average cost	3.0
Cover current and expected costs	Average cost	2.0

19 percent indicated covering costs plus a return on investment, 3 percent showed costs plus a reasonable profit, and 1 percent indicated cost plus a surplus for emergencies. These different cost considerations are consistent with an average cost-pricing policy where no water utility should incur a financial loss. But, as indicated earlier, 33.3 percent of the water utilities in Louisiana reported such a loss in 1971.

Apart from rates charged for residential water use, water utilities generally impose a separate charge for water supplied for fire protection. Of the 41 water utilities which reported charges for fire protection, 75 percent based their charges on "estimates of actual costs" of providing the service, i. e., their charges were based on average costs; 15 percent imposed a "flat charge" which implies that the marginal costs of water for fire protection to the consumer is zero; 10 percent based the charge upon the number of fire hydrants necessary to adequately serve community interests, implying that average cost is used to determine the rate per hydrant. In addition to the 41 water utilities which reported fire protection charges, it should be noted that 22 water utilities provided public fire protection free of charge and at the same time were granted property tax exemption.

Initial charges, including the service charge or minimum charge, generally aim at recovering the fixed costs of the water utility, and may also at times be used to recover part of the operating or variable costs. Of the 162 water utilities which reported a minimum charge, 94 percent employed an average cost consideration in its determination and 3 percent used a possible estimated total cost consideration by charging a flat rate. On the other hand, it is revealing to note that 3 percent of the water utilities base their charge on meter size, which to some extent implicitly reflects the incremental or marginal costs resulting from greater demands placed on a water system by a customer class (Table 58).

Providing water service to outside-limits customers also imposes additional costs to a water utility through extensions of the distribution system and sometimes expansion of plant and storage facilities. Generally, the rates charged for service to these customers are higher than inside-limits customers, particularly where water utilities are municipally owned. Of the 15 municipal water utilities which reported, 11 indicated an average cost consideration in developing the additional

Table 58. Cost Considerations in Establishing the Minimum Charge by Water Utilities in Louisiana, 1971

Statement	Cost consideration	Percent of water utilities
Cover fixed costs	Average cost	87.0
Cover fixed costs plus a return on investment	Average cost	5.0
Cover operating costs	Average cost	2.0
Based on meter size	Marginal cost	3.0
Flat charge	Total cost	3.0

charge to outside limits customers, by stating that the charge was imposed to cover the costs of the service. However, the remaining four water utilities added a flat percentage charge to the monthly water bill. It is difficult to determine on what bases this percentage charge was determined. It may or may not reflect average cost or marginal cost of production.

Water for commercial air-conditioning systems also imposes a greater demand on the water system. As reflected by the survey, the two water utilities which reported rates for lawn-sprinkling provided no clue as to cost considerations since the price charged is a flat monthly rate.

Present water rates for residential use in Louisiana can be criticized on three counts. First, where flat rates are charged, the marginal cost of an additional gallon of water to the consumer is zero, and this stimulates over-consumption and careless use of water.

Second, metered rates are based on average cost pricing and this can lead to over-investment in water supply facilities that in turn fosters promotional rates to encourage full capacity use. Third, the application of uniform rates over time and space are uneconomical since no account is taken of on-peak and off-peak demands, which lead to subsidization of on-peak users by off-peak users.

Marginal Cost Corollaries and Water Rates

Before developing a rate schedule, it is necessary to outline some marginal cost corollaries which further illustrate or provide additional justification for the use of marginal cost pricing.[1] The corollaries are to supplement the basic rate proposal outlined subsequently, and include:

(1) Where optional services are provided such as reconnection fees, meter repairs, installation of any special equipment, air-conditioning and lawn sprinkling, water consumers should pay separate special charges equivalent to the marginal costs of all these services.

(2) In the provision of certain services, such as meter reading, submission of bills, turn-on and off-service, two types of marginal costs will be incurred to the water system: (a) Semi-fixed marginal costs which are those outlays that must be made to serve the user, but are independent of the quantity of water service. (b) Variable

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[1] Burnham P. Beckwith, Marginal Cost Price Output Control, (New York: Columbia University Press), 1955, p. 184.

marginal costs which are those expenditures varying with the amount of water service provided. Where such costs are significant, each should be covered by a price equal to the semi-fixed and variable marginal costs, respectively.

(3) Where different demands are placed on the water system through seasonal, daily, or cyclical fluctuations, a price should be charged equal to marginal costs associated with these fluctuations, with the result in this situation of having prices vary directly with the variations in water use.

(4) Prices based on marginal costs should be equal for all classes of customers. Where water service to different customer classes result in differences in marginal costs, prices charged to each customer class should reflect these differences. Under no circumstances should prices charged to a specific customer class fail to recover the marginal costs associated with that specific customer class. The current use of declining block rates whereby industrial customers are granted cheaper rates than residential customers generally are not designed to reflect differences in marginal costs of each customer class, but instead encourage full-capacity use although not economically justified.

A Proposed Pricing Policy

Preliminary Considerations: Marginal cost pricing as a guide to pricing policy is theoretically simple, but in reality its use can pose serious difficulties of determination, even in well organized business organizations. This does not imply that average cost pricing can be easily determined for it too can be difficult, especially to determine the allocation of common costs of water for different services or customer classes. The allocation process is more or less arbitrary and depends to a large extent upon the viewpoint of the responsible authority.[2]

Faced with the difficult situation of cost identification, the decision to implement a pricing policy should be guided by the degree of efficiency desired in the allocation of relatively scarce resources and at the same time to assure continued water service to consumers. Given the choice between a pricing policy based on marginal or average costs, the former would generate a higher level of efficiency in the allocation of resources that go into water production. It was with this intent that the relative superiority of a marginal cost pricing policy was advocated by Vickery for use in the public utility field.[3]

As in the implementation of a new policy or practice, one of the first considerations should be an evaluation of costs against the prospective benefits. To implement a marginal cost pricing policy with respect to the use of water resources, radical changes in current water pricing practices are necessary. This may be a very controversial issue, particularly with respect to residential water supplies

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[2]Otto Eckstein, _Water Resource Development_ (Cambridge, Massachusetts: Harvard University Press), 1958, p. 62.

[3]William Vickrey, "Some Implications of Marginal Cost Pricing for Public Utilities," _American Economic Review_, Vol. 45, No. 2, May 1965, p. 605.

where public intervention is a fairly common denominator in water allocation. This intervention, however, necessarily makes the market system somewhat less effective, however, Davis and Hanke state:

> . . . the market system can remain effective as an arbitrator of diverse and conflicting interests, promoting the public interest with greater efficiency than alternative arrangements. Information generated by market type transactions makes the choice of goals more rational, identifying the most effective means for achieving the goals. The political reasons for public rather than private provisions of certain services have to go with society's desire to make certain choices collectively. The price system can serve as an aid to choice.[4]

As a first step in the use of the marginal cost principle, the functioning of the market system in price determination should be allowed, to some extent, to pervade every water use. This was emphasized by Fox and Herfindahl who pointed out that no other "single measure" would contribute more to the attainment of efficiency in satisfying the demand for water resources.[5] In a similar vein, Jerome Milliman, one of the most prominent proponents of the market system and marginal cost pricing in the history of the water resources development, had this to say:

> . . . Some of the desirable economic guidelines for price policy are at direct variance with long established precedents. As a practical matter, some needed changes in law and current practices will be long and slow in coming. The task that the water industry has

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[4]Robert K. Davis and Steve H. Hanke, op. cit., p. 5.

[5]Irving Fox and Orris C. Herfindahl, "Attainment of Efficiency and Satisfying Demands for Water Resources," American Economic Review, Volume 56, No. 5, May 1964.

> in educating itself and educating the general public (in the use of a price system) is just part of the uphill struggle to secure greater rationality in the use of water resources. Recognition of the problem, however, constitutes an important step forward.[6]

The greater reliance on market pricing has been recently recommended in a report to the federal government in the construction of federal irrigation projects.[7] Prepared by the National Water Commission established by the U. S. Congress in 1968, the report states that "demand for irrigation water is responsive to changes in price and greater efficiency could be attained in irrigation water use by the adoption of a pricing system. At present, however, efficient water use is not the objective of most water supply agencies."[8] The adoption of the recommendation no doubt would disrupt the historical precedent set by the U. S. Bureau of Reclamation and many state agencies which have been providing water services well below the cost of production.

One of the most persuasive arguments against seeking a purely marginal cost pricing solution in an area of activity such as water resources, is that prices may be out of adjustment in other related sectors. This is especially true when there is positive production relationship between a resource and a product and the price of the

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[6] Jerome W. Milliman, "Price Policies for Municipal Water Service," Journal of American Water Works Association, Vol. 56, No. 2, February 1964, p. 130.

[7] National Water Commission, op. cit., p. 259.

[8] Ibid., pp. 256-257.

latter is effected by some force external to the market. For example, the price support of rice which is a voluminous water user, not only misallocates the product, but also the resources which go into the production. If the support price is higher than the market price, farmers may be encouraged to use larger amounts of water than necessary. This situation prevails because price of water is often contingent upon a share of the crop whose support price may be out of adjustment with its market price.

An effective water pricing system should generate the incentives for the water agency to make its pricing policy serve the ends of efficiency. The profit motive gives private producers an incentive in many cases to follow marginal pricing policies. Public agencies, however, may lack this incentive because their budgets are not entirely dependent upon revenues they collect from user charges. An essential part of any effective policy will have the agency's budget depending appropriately on the revenues collected from pricing.

Based on these preliminary considerations an effective pricing policy for water resources should:

(1) Tend to approach marginal cost pricing in the sense of making beneficiaries pay for what they receive and in distinguishing among consumers the various differences in service costs.

(2) Respond to changes in cost with changes in price.

(3) Adjust to departures from marginal cost pricing in related sectors such as deviation from marginal cost pricing of products utilizing large amounts of water.

(4) Contain incentives (profits) for the water system to pursue efficient pricing policies, and

(5) When average costs are decreasing, a marginal cost pricing policy will generate a financial deficit and may result in terminating the operations of a water system.

The Policy Proposal

Residential Water Use: An improved pricing policy for water resource use in Louisiana should, in the first instance, be based upon an evaluation of current pricing policies and their effect on efficient allocation of water among the different uses and user groups consistent with the social, economic, and political goals of society.

Marginal cost pricing approach should be a guide and should recognize these goals as constraints associated with water use. These social and political goals often conflict with economic goals based upon relevent economic criteria. Marginal cost pricing is a rational economic principle in the allocation of scarce water resources. Where social and political goals take priority over rational economic criteria, the implications should be made clear to the community. Vickrey states:

> . . . the principle of marginal cost pricing is not in practice to be followed absolutely and at all events, but is a principle that is to be followed in so far as this is compatible with other desirable objectives, and from which deviations of greater or lesser magnitude are to be desired when conflicting objectives are considered. On the other hand, I propose to maintain that marginal cost must play a major and even a dominant role in the elaboration of any scheme of rates or prices that seriously pretend to have as a major motive the

> efficient utilization of available resources and facilities.[9]

As mentioned previously, a water system incurs semi-fixed and variable marginal costs of production in the provision of water service. In view of this, it is recommended that the basic rate proposal relate to a seasonal two-part tariff, where the semi-fixed marginal costs are to be recovered by a fixed service charge, and the variable marginal costs to be recovered by a per-unit charge. It should be noted that the fixed service charge is independent of the volume of water consumed whereas the per unit charge will vary depending upon the volume of water consumed during a given season. Being seasonal, the per-unit charge will require a higher rate during summer months than in winter months to reflect the additional costs which are likely to be placed on the water system.[10]

The service charge, being fixed, relates to the costs which must be incurred to serve a customer and include meter reading, billing, accounting equipment and part of other administrative costs. As the number of customers increase, additional costs will be incurred to serve these customers whether they actually consumed water or not. The

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[9] William Vickrey, op. cit., p. 605.

[10] A similar proposal was recommended by H. H. H. Afifi for use in Illinois. Whereas Afifi recommended "the seasonal marginal cost of the peak and off-peak load," the current proposal is different in that the water utility will need two basic rate schedules, i. e., one for winter months and another for summer months to reflect higher marginal cost in the latter season. Afifi proposal will require four rate charges -- two in each season to reflect off-peak and on-peak marginal costs. See H. H. H. Afifi, op. cit., p. 273.

service charge therefore may have to be adjusted to reflect these additional costs.

Marginal cost pricing, as mentioned earlier, becomes difficult to implement when water utilities are characterized by decreasing average total cost of production. As a result, the proposal herein will still generate an income deficit to these water utilities. Several methods of eliminating this income deficit have been suggested depending upon the economic and political goals of government.[11] The two most common methods are: (1) the provision of a government subsidy, and (2) an increase in the service charge. The provision of a subsidy is likely to promote inefficiency in resource use. However, Davis and Hanke argued that a subsidy generated by a tax on local property may remedy this deficiency because the supply of land is fixed and the distorting effects associated with other forms of taxation can be avoided.[12] In addition, since the availability of water service tends to increase property values, it is argued that the property owners should be required to pay for such benefits.

With respect to an increase in the service charge, one has to refer to the Hopkinson cost classification in water utilities.[13] Based

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[11] J. Hirshlerfer, James C. DeHaven and Jerome W. Milliman, op. cit., pp. 90-93.

[12] Robert K. Davis and Steve H. Hanke, op. cit., p. 97.

[13] Louis Ayres, "Determination of Water Rate Schedules," Journal of American Water Works Association, Vol. 44, No. 3, March 1954, pp. 193-195.

on this classification there are three classes of costs: (1) customer costs,[14] (2) commodity costs,[15] and (3) capacity costs.[16] The increase in the service charged will be directed to recover capacity costs since this cost category generally results in the difference between average cost and marginal cost. It should be pointed out that this increase in the service charge may not be necessary, if special charges such as extension fees or fire protection charges cover all capacity costs incurred. In cases where this does not occur, the increase in the service charge, may be captured from the consumer's surpluses realized by marginal cost pricing when average costs are declining.[17]

It should be pointed out that the marginal costs referred to relates to the short-run. Pricing on short-run marginal costs is relevant since water systems are constructed with a given capacity and are therefore faced with the short-run problem of selling their output at this capacity. In addition, the consumers decision to purchase water is in the nature of a short-run agreement and with no committment

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[14] Customer costs are a function of the number of customers and include meter reading, billing, collecting, and accounting services.

[15] Commodity costs are a function of the volume of water and is comprised of costs associated with actual deliveries of water.

[16] Capacity costs are those costs associated with the ability of a utility to serve or deliver capacity during a specific period of time. They reflect the ability to meet peak demands for water.

[17] H. H. H. Afifi, op. cit., p. 295.

to purchase water at a future date.[18]

Apart from decreasing average costs, a water utility may experience increasing average costs as well. In such a case, a price charged equal to marginal cost may get a negative reaction on the part of residential water consumers. If the water system is municipally owned, the local authority may wish to divert this revenue surplus or justify its maintenance at an acceptable level, although some resource misallocation would result. However, apart from this relative misallocation, the degree of economic efficiency achieved in water resources production through marginal cost pricing will be greater than a pricing policy based on average cost pricing. On the other hand, where the system is privately owned, the revenue surplus may be justifiably retained for purposes of additional investment, taxed away by any appropriate fiscal measure consistent with the goals of government, or retained to offset income deficits incurred.

Many criticisms have been levelled against average cost pricing and one may question the proposal stated herein, since essentially it is an average cost approach when the water system are operating under decreasing cost conditions. This pricing proposal differs from average cost pricing in many ways. First, it ceases to be average cost pricing once marginal cost exceeds average cost. Second, it comes fairly close in attempting to provide optimum resource allocation, by charging a per unit price equal to marginal costs of production. Third, and most

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[18] Jack Hirshleifer, James C. De Haven, and Jerome Milliman, *op. cit.*, p. 97.

important, it takes into consideration off-peak and on-peak load pricing to be discussed below. Fifth, it can prevent over-investment in water supplies since such investments will be undertaken only if customers are willing to pay the additional costs. And, finally, this proposal rules out the charge of flat rates which is still relatively common in Louisiana.

Prices equivalent to marginal costs of different volumes of water can be charged to reflect the corresponding differences in costs. It is this reflection of cost differences that the current use of declining block rates generally fails to acknowledge. Block rates, however, should reflect the incremental costs associated with all customers under identical cost conditions, and should differ when such costs are different by customer class.

As mentioned before, the demand for water fluctuates within a given day, or during a given time period within a year. These fluctuations are of serious consideration since they affect the service capacity of the water system. In terms of residential water use, demands are greater in late afternoon than in morning. Such situations call for on-peak and off-peak pricing as reflected by the fluctuations in marginal costs associated with each time period. Since marginal cost is a function of output, it will be necessary to determine the cost of providing a fractional marginal unit of capacity, based on the system's reserve factor. If this fraction is 25 percent, then marginal costs will be equivalent to one-fourth of total cost. Milliman claims different rates for peak-demands already exist in the cities of

Milwaukee, Kansas City, and St. Louis.[19] In Milwaukee, metering equipment operates for 30 days unattended, yet it summarizes on punched tape the flow to a single customer at 15 minute intervals.[20] A system of peak-load pricing is already in existence in some other public utilities such as the telephone and transportation industries, where the services are not storeable. This is not so with water which is to a large extent storeable and thereby permits the assessment of storage costs and a relatively easier determination of marginal costs, not only with regard to fluctuations in peak demands but off-peak as well.[21]

One of the major objections to marginal cost-pricing is the problem of how to measure marginal costs. Where production water meters can be acquired for this purpose, relatively no difficulty should be presented in a reasonable estimation. However, where they do not exist, the marginal cost can be determined by an examination of data pertaining to previous years and computing an average marginal cost. These data may be used not only for current purposes, but for projection of future costs in order to avoid frequent rate revisions.

Water utilities supplying residential water service currently have a series of other charges associated with water use. One of

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[19]Jerome Milliman, "Policy Horizons for Future Urban Water Supply," Land Economics, Vol. XXIX, No. 2, May 1963, p. 123.

[20]William L. Patterson, "Practical Water Rate Determination," Journal of American Water Works Association, Vol. 54, No. 8, August 1962, p. 910.

[21]W. Arthur Lewis, op. cit., p. 250.

these charges is for fire protection which is still a highly debated and controversial issue. The provision of this service demands a "readiness to serve" on the part of the utility and as a result the quantity of water used fails to reflect the actual costs in the act of fire-prevention. Fire protection imposes excessive and unpredictable demands on the water system, somewhat different from those of peak demands which persist for relatively longer periods of time.

Because of extra capacity required, the case for marginal cost pricing is plausible since the price charged should be equal to the semi-fixed and variable marginal costs of providing the service. Many water utilities in the first instance are designed to provide service to residential users and the demand for fire protection means additional investment, the costs of which should serve as a guide in the determination of the associated marginal costs. One way of determining this added cost is to compare the costs and related charges with and without fire protection and set a price equivalent to the difference in costs. This method of incremental price will further meet the standards of the National Board of Fire Underwriters which advocates a charge on the basis of the incremental capacity required over the capcaity for normal use, plus the clearly separable costs ascribable to fire protection.[22]

The appropriateness of marginal-cost pricing in determining fire protection rates will determine the willingness of customers to pay for

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[22] Louis Ayres, op. cit., p. 201.

it since providing the service is optional to the water utility. There is no coercion on the part of the water utility in providing the service except possibly where political play comes up in the cases of municipally owned utilities. In Louisiana, as reflected by the survey, the current practice places an annual or monthly lump-sum charge based on the number of fire hydrants. If charges are to be based on a hydrant, the marginal cost per hydrant can possibly be determined by dividing the total marginal costs of the fire protection service by the number of hydrants. Some utilities base fire charges on meter size, a practice which implicitly considers cost of reserve capacity as the cost to be recovered.

Another charge used in water utility practice is that associated with air-conditioning and lawn sprinkling, which places a seasonal demand upon the water utility, specifically during summer months. These seasonal demands are more sensitive to price changes than any other form of residential water use and, as such, should be subjected to marginal cost pricing.[23] Seasonal demands can result in under-utilization capacity of the water system. However, it should be noted that seasonal demands are cyclical and are relatively more predictable than fire protection. The seasonal marginal cost pricing approach may help both the residential consumer and supplier to identify the costs and benefits of water services and to arrive at a more rational allocation of water resources.

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[23] Charles W. Howe and F. P. Linaweaver, _op_. _cit_., p. 13-32.

Municipally owned water utilities generally charge higher rates to customers served outside the political boundaries of the municipality. To serve these customers requires additional costs in plant size, pumping and distribution, and this makes marginal cost pricing appropriate to capture these incremental costs.

Water utilities normally charge for the installation of meters, extensions, connections, and occasionally for reconnection in the case of reestablishing delinquent customers to the system. As discussed earlier, one of the major marginal cost pricing corollaries is to charge a separate price to cover the incremental costs of the different services. The provision of the forementioned services involves additional costs and as a consequence customers should be charged accordingly.

At this juncture, it should be pointed out that water utilities are not homogeneous units of production and differences in marginal costs are bound to occur. Nevertheless, the economic philosophy and rationality behind the marginal cost pricing principle has withstood many storms of controversy, in its application to other services. As Vickrey notes:

> Marginal cost pricing must be regarded not as a mere proposal to lower rates generally below average cost level, but rather as an approach which implies a drastic rearrangement of the patterns and structure of rates. Indeed it is this restructuring of rates that is likely to be the greatest contribution of marginal cost pricing to improvement of the over-all efficiency of our economy . . . The issue is not primarily one of subsidized versus nonsubsidized operations . . . but one of whether the pattern of rates should be based on tradition, inertia, and happenstance, or whether it is to be developed by

> careful weighing of the relevant factors with a view to guiding consumers to make an efficient use of the facilities that are available.[24]

Agricultural and Industrial Water Uses: In Louisiana, as shown previously, water used in industry and agriculture is primarily self-supplied with the exception of irrigation canal companies where the charge is based on a proportion of the rice crop as negotiated by contract. An appropriate pricing policy for these irrigation canal companies should be based on the marginal cost pricing policy outlined previously since the crop-sharing policy may or may not reflect the marginal cost of water production.

With respect to self-supplied agricultural and industrial users, a pricing policy based on the marginal cost of production may not be relevant. However, two methods could be used in order that decisions may be made to rationally allocate the resource among agricultural and industrial users obtaining water from a common source. These methods are: (1) the assignment of pro-rata water rights or quotas; and (2) the imposition of "use" taxes.[25]

The use of the pro-rata or quota method involves the adjudication of water rights and an acceptable annual recharge rate in order to maintain a safe yield and to avoid salt water intrusion in aquifers of

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[24] William Vickrey, "Marginal Cost Pricing for Public Utilities," Price Theory in Action, by D. H. Watson (Ed.), (Boston: Houghton Mifflin Company), 1965, p. 276.

[25] Jerome W. Milliman, "Commodity, Price System, and Water Supplies," Southern Economic Journal, Volume XXII, No. 4, April 1952, pp. 426-437.

the water table. The safe yield level of the water table will have to be determined by government as a basis in allocating water rights based on the needs of both current and prospective users. The assignment of quotas may pose no problem where water rights have already been established as in the Riparian doctrine where water use is contingent upon ownership of land on the banks of a stream. However, where pumpers have no claim to Riparian land, the Appropriation doctrine may be necessary to assign water rights on a priority bases and not on the ownership of land.

The use of the pro-rata method is advantageous in three respects: (1) it is simple and direct, (2) it replaces the commonality of rights to water use by assigning specific shares to each user, and (3) it tends to promote efficient allocation of scarce water resources since rights can be traded among water users. The trading of water rights would stimulate each owner to consider the value of his right and his utilization of water in alternative uses. This practice is somewhat similar to that of the mutual irrigation companies in Utah and California, where shareholders are free to trade their shares of water contingent upon the demand of others.[26]

Apart from the advantages of the pro-rata method, it should be noted that the method is not without its difficulties in its implementation. Some of these difficulties include: (1) the definition and determination of an "equitable" apportionment; and, (2) the

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[26]Wells A. Hutchins, _op_. _cit_., p. 35.

establishment of a safe level of the water table. This level is subject to replenishment as well as depletion and therefore quotas may have to be reappraised from time to time.

The second method of a "use tax" is generally regarded most appropriate since its aim is to remedy the divergence between private costs and social costs created by "spill-over" effects or externalities through excessive pumping by a user. That is, some users overdraw, thereby lowering the water table and causing other pumpers to incur higher pumping costs. The benefits in this case accrue to the original pumper whose action of excessive pumping has created social costs to the community. With the use tax each pumper is levied a tax to recover the difference between the marginal social cost and marginal private cost. This is shown in Figure 9 where the optimum level of water is OA, the use tax of QD, and the price of water to the pumper equal to AQ. Once the water system is established, under a competitive situation, the level of water used would be OB which is greater than OA, and water would be priced at BP, which is equivalent to the cost of pumping. Through this use-tax method, each pumper will compare his marginal value in use of water and his marginal cost of pumping in deciding how much water to pump. The marginal value in use will be the value of the marginal product since water is used as an intermediate good in the production of other goods for the market. The aim of the use-tax solution is to induce the pumper to consider the marginal social cost of pumping as well as his marginal private cost and thereby to discourage the excessive use of water.

The "use-tax" solution which will provide for efficient use of water resources is not without its difficulties. The most serious difficulty relates to the measurement of marginal social cost since increased pumping costs in the future will create a larger divergence between marginal social cost and marginal private cost. In addition,

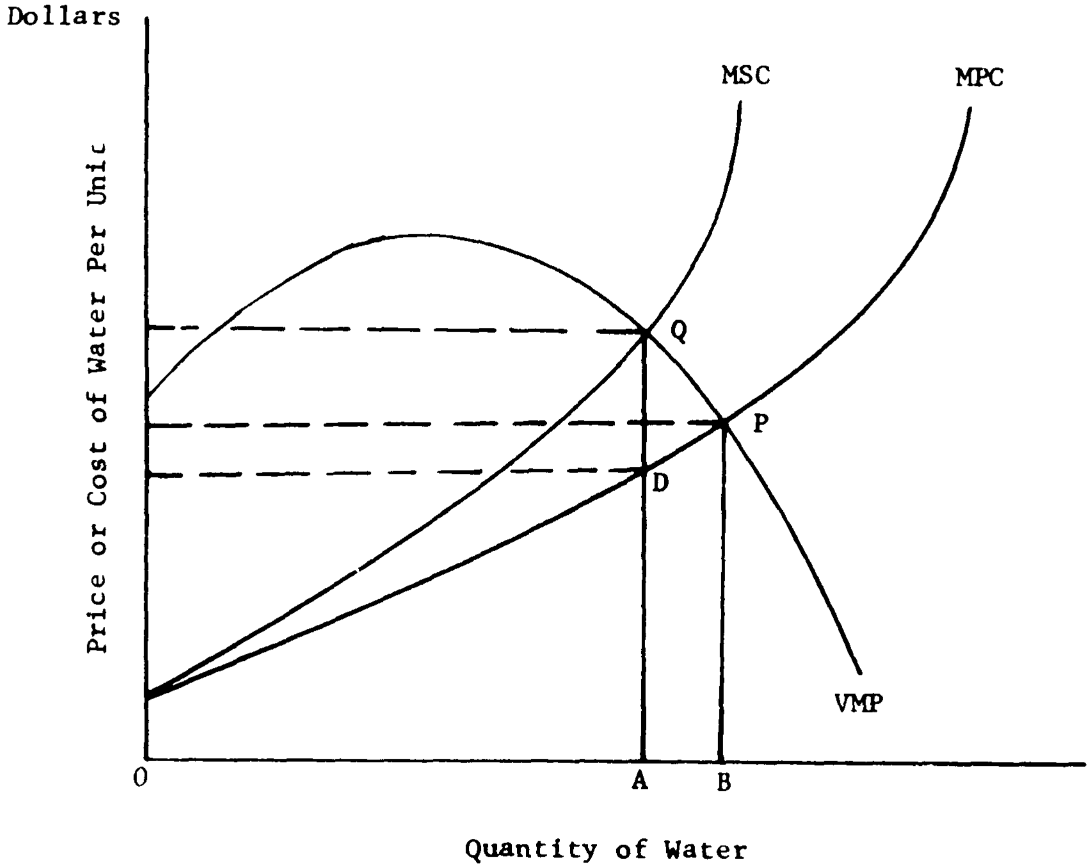

Figure 9. Pricing of Water for Agricultural and Industrial Uses.

this method may pose administrative difficulties and rationality in water use over time. The pro-rata method, apart from its inherent deficiences, is generally most attractive because of its simplicity, its ease in allocation of water where water rights are not specified, its adaptability to trading of water rights, and the benefits are realized by private water users as opposed to collection and distribution of tax funds by government under the use-tax method.

CHAPTER IX

SUMMARY AND CONCLUSION

In Louisiana, relatively little attention has been directed to water supplies and water pricing. Only within the past decade has the state government taken a keen interest in conservation of water resources. As competition for water intensifies, a guide to efficient allocation of water resources rests heavily on the price charged for the use of water. In this sense, this study is unique in that it represents the first effort to appraise water pricing techniques and policies in Louisiana.

Generally, this study evaluates current price structures and pricing policies for residential, agricultural, and industrial water uses, with the aim of exploring marginal cost pricing as a possible technique for more efficiently allocating a resource approaching scarcity in Louisiana. To obtain basic primary data from water suppliers a questionnaire was designed and forwarded to 317 water utilities in Louisiana. Data collected pertained to populations served, the sources and economic costs of water supplies, pricing structures and policies, and the financial status of the water utilities. Secondary data were utilized to determine water prices for agriculture and industry. The analysis of all data centered primarily on costs and pricing policies, and dealt with the three broad categories of water use, namely industrial, agricultural, and residential. To put this Louisiana study into perspective, however, an overview of water prices in other regions was also included.

Water resources play a dominant role in the social and economic development of a community, a state, or a nation. As a valuable natural resource, water's economic availability and pattern of use affect every living thing. Although water may occur in physical abundance, its availability and use to consumers is conditioned upon the function of water-supplying institutions which assemble, store, treat, and distribute water of an acceptable quality at an appropriate time and at a "reasonable" price. It is the "reasonableness" of price which is frequently the focus of controversy since society generally regards water as a "cheap" economic good.

An examination of pricing theory for water resources reveals that the water market is highly imperfect because the forces of supply and demand are not permitted to interact freely and thus allow prices to allocate the resource. These imperfections stem from: (1) water rights laws, (2) technological indivisibilities or the presence of externalities which in turn create a divergence between private and social costs, (3) public regulation and intervention in the provision of water supplies, (4) the social image of water resources as a "free" or "public" good where each individual is inherently entitled to a minimum supply necessary for his physical survival, and (5) the character of production and distribution which makes the water utility company a natural monopoly.

Due to these imperfections the water market is one generally characterized by monopoly power. Apart from this monopoly power, current pricing theory indicates that the price charged for water use is generally regulated at a level to recover the average costs of water production, i. e., an average cost pricing approach.

A review of water pricing policies in arid and humid regions in the United States indicated that pricing policies among these regions differed depending upon the availability of water supplies, the organization of the water supplying agency and the specific uses of water supplied. Water for residential use was supplied primarily by public water utilities as regulated monopolies where the most common pricing policy involved a metered system of declining block rates which was coupled with the inclusion of a minimum monthly charge.

Based on this study, the average monthly water consumption for a family of four in Louisiana was estimated at 10,000 gallons. Using this level of consumption, a comparison was made of the monthly family expenditure on water in 12 states representing regions ranging from less than 20 inches to over 50 inches of rainfall annually. In the arid regions where rainfall is less than 20 inches annually, the average family expenditure was \$3.00 per month; in the semi-humid region with rainfall of 30-49 inches annually, it was \$4.54; and in the humid regions characterized with 50 inches or more of precipitation, the average expenditure was \$4.70 per month. Among the 12 states the average monthly expenditure ranged from a high of \$5.83 in Oregon to a low of $1.66 in Nevada. Louisiana ranked sixth within this range with an average expenditure of $3.41.

A notable difference in pricing policies was observed for water used in agriculture. In the arid western states where the Appropriation Doctrine exists, the U. S. Bureau of Reclamation was the most common water supplying agency for agriculture. The pricing policy of the Bureau is based on the economic ability of farmers to pay for water and on most occasions the contract price is not designed to recover the average costs of production. Current payments by farmers were estimated at about 75 percent of the actual costs of production. Outside the Bureau, there are state public agencies providing agricultural water below cost, with the deficit financed generally by land taxation. In some states private, mutually organized irrigation companies issue shares on which a toll is levied to cover operation expenses of the company supplying the water.

In the humid areas of the United States, the primary supplies of agricultural water are derived from projects developed by the Corps of Engineers, some state agency, or may be self-supplied by farmers. Generally, the Corps of Engineers does not impose a direct charge for irrigation water, but instead uses a cost-sharing plan whereby 70 percent of a project's cost is borne by the Federal government and 30 percent by the farmers. At the state level, Water Control and Improvement Districts impose a variety of charges which are based on land taxation, a flat charge per acre of cultivated land, or only a pumping fee. Based on land taxation, the average charge for water is about

$3.25 per acre; the flat charge ranges from $1.00 to $5.00 per cultivated acre; and the pumping fee ranges from $6.53 to $13.06 per acre-foot of water. Wide variations exist among these charges. For example, in the southern plains of Texas the price charged ranged from $1.82 to $72.76 per acre-foot of water. A comparison of 22 states excluding Texas revealed the price ranged from a low of $2.21 per acre-foot of water in South Dakota to a high of $31.37 per acre-foot in California.

Pricing of Residential Water in Louisiana: In Louisiana, water for residential use is generally provided by water utilities which have a regulated monopoly status. These water utilities are either owned by private individuals, the municipal government, or by a group of private individuals in the form of a nonprofit corporation. The regulated features of these water utilities are centered primarily upon pricing policies and water quality standards. Rates of all privately owned water utilities are regulated by the Louisiana Public Service Commission, while the rates of the nonprofit corporations are determined by the Farmers Home Administration which supplies their investment funds. Rates of municipal water utilities are regulated by a municipal council or some other appointive public body.

The water market served by water utilities in Louisiana are relatively small, with 68 percent of the water utilities serving populations of 1,000 or less. Although all water utilities supply water for residential use, 10 percent also supply water to commercial and industrial customers. However, in terms of pricing, only one percent of the water utilities offer commercial and industrial customers lower rates than those charged to residential customers.

Although the water market served by water utilities in Louisiana is small, there are wide variations in consumption of water by residential customers. The average family consumption for this study was estimated at 10,000 gallons per month or roughly about 84 gallons per capita per day. The data revealed that in 1971 consumption, ranged from a low of 50 gallons per capita per day to a high of 150. Within this range, consumers supplied by FHA water utilities consumed an average of 75 gallons per capita per day; private water utility customers averaged 110 gallons per capita per day; and municipal water utility customers consumed 125 gallons per capita per day.

In Louisiana, supplies of water for residential use come from both ground and surface sources, with ground water supplying about 96 percent of all water utilities. Less than one percent of the water utilities purchased water from other utilities for distribution to their customers.

Municipal water utilities distribute water to an average of more than 200 persons per mile of distribution line, whereas, private and FHA water utilities serve an average of 75 persons per mile.

Investment in distribution lines in these two latter classes of water utilities constitute an average of 48 percent of their total capital investment while municipal water utilities have about 43 percent of their investment in distribution lines.

More than half (57 percent) of the water utilities surveyed did not keep records of the quantity of water produced for residential use. This was particularly true for water utilities that charged a flat monthly rate. Not knowing the amount of water produced for distribution makes the determination of water losses impossible. However, water losses by water utilities that maintained records was reported to range from 15-25 percent of water production.

Investments by water utilities are generally made to meet future as well as current water demand. Although water utilities in Louisiana serve relatively small populations, 61 percent incurred total investments of $50,000 or more, with 36 percent investing $100,000 or above. Most private water utilities reported a total investment of $25,000 or less while practically all municipal water utilities incurred $100,000 or more. The FHA water utilities reported an average investment of about $65,000. The major part of total investment by municipal and FHA water utilities was for the construction of distribution lines, while the major part for private water utilities was for the construction of wells. In addition, about 72 percent of the private water utilities had a per capita investment of $100 whereas FHA and municipal water utilities had an estimated investment of $150 per capita.

The level of capital investments by water utilities has a direct bearing on the level of annual fixed costs incurred in the supply of water. Of the water utilities surveyed, annual fixed costs as a percentage of total annual costs ranged from a high of 43 percent at a population of 500 or less to a low of 31 percent at a population of

10,000-25,000. On the basis of ownership of water utilities, annual fixed cost accounted for 49 percent of total annual costs among the FHA water utilities whereas it averaged 32 percent among private and municipal water utilities.

Regression analysis was used to determine the relationship between the size of population served and the total annual cost of operating the water utilities surveyed. Analysis of the results indicated that there was a positive linear relationship between these two variables, implying that these water utilities were apparently in the decreasing average cost stage of production. This cost situation generally characterizes the operation of public utilities and forms the basis for the recommended pricing policy of a two-part tariff to be used by water utilities in Louisiana.

The management of a water utility is usually interested in its annual average total cost (ATC) per capita. Analysis revealed wide variations existed in ATC ranging from a high of $26.30 when serving less than 100 individuals, to a low of $10.60 per capita when serving a population between 10,001-50,000. On the basis of ownership of water utilities, the ATC per person served was $13.37 for municipal water utilities, $16.63 for FHA water utilities, and $17.74 for private water utilties.

In Louisiana, 24 percent of the water utilities surveyed used a system of flat rates, 71 percent used a system of metered rates, and 5 percent a combination of flat and metered rates. Water utilities using flat rates are primarily located in the south central region of Louisiana and serve relatively small populations, with 69 percent serving a population of 300 or less. No water utility which served a population above 10,000 used flat rates. In addition, 85.5 percent of the water utilities with flat rate systems were privately owned while the remainder were municipally owned in 1971. The FHA water utilities do not use flat rates. Flat rates ranged from a minimum of $1.50 to a maximum of $7.50 per month, with the average charge being $4.00 per month.

In Louisiana, metered rates are generally based on the decling block method where the price per block decreases as the quantity of water consumed per block increases. Within this system of block rates, all water utilities utilize at least two blocks while a few of the larger utilities have as many as five blocks. Municipal water utilities generally have the largest number of rate blocks since they serve a larger and more heterogeneous population.

An important element in the use of declining block rates is the difference in price charged among the different blocks. This difference reflects the discounts given at each step in the rate schedule as the customer's water consumption increases. For the purposes of this study, the difference was expressed as a ratio in the price charged between the second block and the last block since most water utilities consider the charge assigned to the first block as the minimum charge associated with residential water use.

Of the water utilities reporting, 52 percent had a ratio ranging from 1.0-1.9 implying that the rate charged in the last block ranged from either the same to slightly less than half the price of the second block. In 26 percent of the water utilities the ratio ranged between 2.0-2.9, and for 22 percent of the water utilities it was 3.0 or more. The difference between the two blocks was negligible where populations served were small, but increased appreciably as populations served increased.

Among the municipal water utilities, the ratio expressing the difference in rates between the second block and last block of rate schedules was generally 3.0 or more while in private water utilities the ratio commonly ranged between 2.0-2.9 and in FHA water utilities 1.0-1.9. As a result the difference in rates or discounts in rates between the second and last block was largest in the rate schedules of municipal water utilities and smallest among the FHA water utilitites.

Among the three classes of water utilities, considerable variation was found in the monthly charge for the average family consumption of 10,000 gallons of water. For municipal water utilities the charge on the average was $6.74 per month while for private water utilities it was $7.90, and FHA water utilities $10.08.

The variations in water rates through price discounts for consuming a larger volume of water were more observable when the charge for 10,000 gallons was compared to the charge for 5,000 gallons of water. The average charge for 5,000 gallons by municipal water utilities was $4.48, by private water utilities $4.95, and by FHA water utilities $7.38. Compared to these charges, the charges for 10,000 gallons of water, were 50 percent, 59 percent, and 39 percent higher, respectively.

Regional variations in the charge for residential water were also noted. Regionally, the charge for the average family consumption per month ranged from a low of $6.95 in the South Central region to a high of $10.11 in the North Central region. The state's average charge was $8.24 per month which is an estimated 0.9 percent of the average monthly family income in Louisiana.

A common practice in water utility pricing policy in Louisiana is the use of a minimum monthly charge. This charge among utilities ranged from less than $1.00 to a high of $7.00 per month, with the charge being lower as population served increased. Generally, both private and municipal water utilities had a minimum charge of $3.00 or less per month whereas all FHA water utilities had a minimum charge ranging from $3.00 to $7.00 per month. In addition to the minimum charge itself, a very important element, apart from the volume of water allowed, is the minimum charge per 1,000 gallons to the consumer. In this respect, FHA water utilities had the highest average charge of $1.50 per 1,000 gallons per month while the municipal and private water utilities charged about $0.75.

Special charges imposed by water utilities included outside area-limits charges, nonrecurrent charges (tapping fees, customer deposits, meter installation charges and reconnection fees), surcharges or demand charges (air-condition and sprinkling), and fire protection charges. Municipally owned water utilities generally charged outside limit customers an additional $1.00 to $4.50 per 1,000 gallons of water per month. However, a few water utilities added a flat percentage of between 25-30 percent of the monthly water bill to the outside limit customer. Among the nonrecurrent charges, the tapping fee ranged from $10.00 to $50.00 with most common charge of $25.00. Most municipal water utilities charged $30.00 or more while the FHA and private water utilities generally charged less than $30.00. Customer deposits were required primarily by water utilities having a system of metered rates and these ranged from $5.00 to $30.00 with the most common charge being $20.00. Private and municipal water utilities asked for an average deposit of $15.00, whereas FHA water utilities required an average deposit of $25.00. Meter installation charges were required primarily by private water utilities and varied from $10.00 to $25.00. Reconnection fees were most common among private and municipal water utilities and ranged from $3.00 to $6.00.

Surcharges or demand charges normally relate to water used for water-cooled air-conditioning and lawn sprinkling. Water utilities in Louisiana rarely have special rates for these two water uses, but it should be noted that two water utilities reported charges of $1.28 per ton per month for air-conditioning and $3.50 per month for lawn sprinkling.

Water utilities in Louisiana provide both "public" and "private" fire protection. For private fire protection, municipal water utilities charged $50.00 per hydrant per year while private water utilities charged $120.00 per hydrant per year. Public fire protection was most commonly provided by municipal water utilities, half of which provided the service free of charge in return for tax concessions or financial subsidy from the municipal government. The average charge by the remaining half of the municipal water utilities was $25.00 per hydrant per year while private water utilities have an average annual charge of $30.00 per hydrant. FHA water utilities in Louisiana impose no direct charge for fire protection.

Although water utilities expect to generate an adequate amount of total revenue from water rates and other special charges to at least recover the total cost of production, the future growth and stability of each water utility hinges upon its ability to provide necessary maintenance and to undertake new investment to meet growing water demands. Continued financial strength is determined largely by the size of net income generated from current operations. Faced with regulated rates which change rather slowly, the net income, therefore, is dependent to a large extent on the efficiency of current operations and concomitantly on the level of the average total cost of production.

In Louisiana, as reflected by this study, only two out of three water utilities realized a net income from operations in 1971, i. e., their total annual revenues exceeded their annual total cost. However, it was noted that for the water utilities which did not realize a net income, the total annual revenue did cover the annual variable costs of production, but was insufficient to also cover the total annual fixed cost of production.

Since the costs incurred and the revenues generated by a water utility's operations is contingent upon the size of population served, this study revealed that all water utilities which served a population between 15,001 to 25,000 realized a net income. In addition, 75 percent of the water utilities which served populations above 25,000 realized a net income also. However, at a population range of 3,001-5,000 an equal number realized a net loss as did a net income.

Apart from market size, the type of ownership of water utilities also has a direct bearing on cost-revenue relationships and net income. An examination on the basis of ownership indicated that 93.6 percent of the FHA water utilities realized a net income in 1971, along with 60 percent of the municipal and 53 percent of the private water utilities.

An analysis with respect to the location of the water utilities and their respective financial conditions indicated that 76.6 percent of those which realized a net income were located in the northwestern region of Louisiana. This relatively high percentage is accounted for by the fact that the largest number of FHA water utilities are located in that region. On the other hand, the largest percentage (43) of water utilities which experienced a net loss were located in the southeastern and south central regions of the state. Most of the water utilities which are privately owned and have unmetered consumption are located in these latter two regions.

Of the water utilities which reported a net income, 64 percent realized a net of $5,000 or less. From the standpoint of ownership, about 50 percent of the municipal water utilities gained a net income of $10,000 or more while 97 percent of the FHA water utilities realized a sum less than $10,000. A net income of less than $500 in 1971 was reported by 68 percent of the privately owned water utilities.

Of the 70 water utilities which reported net losses, 84.3 percent realized a loss of $5,000 or less. Actually, the largest number (32) realized a net loss of $1,000 or less. The municipal water utilities incurred the heaviest losses as well as the highest level of net income.

The system of water rates appears to have a direct bearing upon the financial condition of the water utilities as 87.2 percent of those which charged flat rates realized a net loss in 1971. By way of contrast, 81.3 percent of those using metered rates realized a net income. Moreover, of those using a combined system of flat and metered rates, about an equal number experienced a net loss as did a net gain.

<u>Pricing of Agricultural Water</u>: Agriculture is the second largest user of water in Louisiana, superseded only by industry. Since rice irrigation accounts for 94 percent of all agricultural water use, this study examined the cost-pricing of water used for production of that commodity. Water used for rice irrigation comes from both ground and surface sources with a larger proportion obtained from the latter source. However, during the last five years, the use of ground water increased by 33 percent whereas the use of surface water declined by

4 percent. Water for rice irrigation is generally obtained from canal companies or from farm wells.

The cost of water for rice irrigation was determined by examining the costs of establishing and operating a 15 year surface canal and a 35 year subsurface pipeline which obtained water from both ground and surface water sources. The level of investment in a subsurface pipeline to serve a 136.5 acre rice farm was about five times greater than that for a surface canal. Based on an average use of 1.02 million gallons of water per acre of rice, the cost of water through the use of a subsurface pipeline from a surface water source was estimated at \$0.011 per 1,000 gallons while the cost by use of a surface canal was \$0.014 per 1,000 gallons. From a ground water source, the cost was \$0.024 and \$0.028, respectively.

Rice farmers do not pay a direct price for water as do residential users. Where farmers have their own water system, the costs are those of installing and operating the system. Where water is obtained from canal companies, the price paid for water is a contracted portion of the rice crop. On an average, the contract is about 20 percent of the rice crop and one study estimates water cost ranging from \$4.80 to \$13.45 per acre-foot of water. However, the current study estimated that water supplies by a surface canal ranged from \$4.50 to \$8.90 per acre-foot and water supplied by a subsurface pipeline from \$3.61 to \$7.77 per acre-foot.

Although the price of water for agricultural use in Louisiana is based on supply and demand, it is also indirectly dependent on prices in the rice market. Paying for water with a share of the crop amounts to either a flat charge, irrespective of the amount of water used, or a variable charge depending upon variations in yields and price of rice. Apart from this crop-sharing pricing policy of canal companies, the explicit costs paid by self-supplied farmers and Irrigation Districts is relatively low. These low costs may be difficult to support in the future due to depletion of ground water supplies, salt water intrusion, competition from industrial water demands, increased cost of irrigation equipment, and higher land costs, especially in the southwestern region of Louisiana.

Pricing of Industrial Water: Industry is the largest user of water in Louisiana, accounting for about 70 percent of the state's total water use. Most of the industrial water supplies are obtained from surface sources, primarily the Mississippi River which supplies about 79 percent. The major water-using industries in the state are those associated with chemical and allied products, petroleum products, and food products. The major proportion of industry water supplies are used for cooling and as a result are characterized by a high rate of discharge, averaging about 96 percent of total water intake. Practically all major industries have their own water systems, and 70 percent of their water demands occur in the southeastern and south central regions of the state where most industries are located.

Generally, the price of water for industrial use relates only to the costs of obtaining the necessary supplies, i. e., once the capital facilities are established, the current costs of industrial water relate to pumping and transmission costs. Further, since industrial water is used mostly for cooling purposes, a relatively negligible cost is involved for purification or other forms of water treatment.

A local chemical products plant estimated water costs at $0.08 per 1,000 gallons while a metal products plant estimated its cost as ranging from $0.10 to $0.17 per 1,000 gallons of water. On the other hand, for residential water use, the most efficient water utility supplies water at an average cost of $0.30 per 1,000 gallons. This relatively higher cost on the part of water utilities partially explains why most industries develop their own water systems.

Costs of water to industry in Louisiana compare favorably to those in other areas. One study which surveyed industrial plants in 13 states found that these industries incurred costs ranging from $0.01 to $0.21 per 1,000 gallons of water. Furthermore, 50 percent of the plants experienced an average cost of $0.10 per 1,000 gallons. Thus, the costs of $0.08 per 1,000 gallons reported in Louisiana appears reasonable. Of this average total cost, about 60 percent relates to average variable cost and 40 percent to average fixed cost.

In the industrial water market, since 99 percent of the industries are self-supplied and no market determined price is associated with water use, it is difficult to make an economic evaluation of water pricing. However, apart from this, the costs or internal price for industrial water is low in comparison to price charged in the residential sector. Currently, industrial water demands pose relatively no threat to residential demand. But with unrestrained use by the lack of a market price, the threat can well materialize in the near future, especially in the south central and southeastern regions of Louisiana.

A Pricing Policy Proposal: The price charged for water in its different uses serves as the guiding force in the economic allocation of the resource among these uses. However, in addition to economic allocations, social and political considerations influence water pricing to a considerable extent. The economics of water scarcity implies that as long as consumers are willing to pay the cost of having water provided in an adequate quantity and of an acceptable quality, the price mechanism will function.

Water for residential use is the one sector where the water market is well defined and prices can be readily identified. The use of flat rates by some water utilities may be uneconomic. The use of declining block rates by others is discriminatory by charging lower prices as the volume of water consumed increases. Customers served under identical cost conditions should pay the same price for water. Different prices are economically justifiable when they reflect differences in the costs of production.

To economically evaluate the price structure of water utilities, management was asked to indicate the extent to which water rates embody a marginal cost-pricing principle in contrast to average cost-pricing. Marginal cost-pricing consideration was embodied only where the minimum charge was based upon meter size. This was practiced by two percent of the water utilities while 94 percent based the minimum charge on the premise of average costs. In setting the declining block rates, all water utilities indicated that they were based on average costs of production. The same policy was applied in the development of charges to outside-limits customers, and charges for fire protection.

In view of the average cost pricing approach and its inherent economic inefficiency in the allocation of scarce water resources, it is suggested that a marginal cost-pricing policy could be utilized in developing water rates. It should be emphasized, however, that marginal cost-pricing provides no magical solution to the misallocation of water resources.

Because of the difficulty in implementing a purely marginal cost-pricing policy, its use to a large extent should serve as a guide and a possible goal in developing water rates. The primary difficulties relate to the amount of information required and the deficits realized in decreasing cost situations. Apart from this, it is economically superior to average cost pricing, as a rational means of allocating a scarce resource.

The goals in providing water service are economic, social, and political in nature. In order to achieve these goals and at the same time to minimize misallocation of water resources, an effective and realistic pricing policy should: (1) tend to encourage marginal cost-pricing wherein beneficiaries pay in proportion to water services received; (2) respond to changes in costs with changes in price; and (3) assure reasonable profit incentives for the water utility.

Since water utilities incur both semi-fixed and variable marginal costs of production, a recommended pricing policy based on marginal cost pricing relates to a seasonal two-part tariff. The first part of this tariff would be a service charge equivalent to the semi-fixed marginal costs while the second part would be a per unit rate equal to the variable marginal costs of production. Being seasonal, the per unit rate would be higher in summer months than in winter months.

Water utilities may be characterized as having decreasing average costs of production and, as a result, a marginal cost pricing policy would generate an income deficit. The alternatives to eliminate this deficit include either a government subsidy generated by a tax on local property or an increase in the service charge.

If water utilities over time incur increasing average costs, the per unit charge equal to the marginal cost of production will result in a financial surplus to the water system. This surplus may be justifiably retained for future investment to meet anticipated increases in the demand for water, or taxed away by appropriate fiscal measures consistent with the economic and political goals of government.

The use of marginal cost-pricing may require radical changes in the development of rate structures for water utilities. The current pricing policy based on declining block rates may still be retained, provided the marginal costs of production of the water utility are declining. However, if marginal costs are increasing, the water utility may have to base its pricing policy on increasing block rates instead of the traditional decreasing block rates. Therefore, the use of block rates is contingent upon changes in the variable costs of water production and concomitantly the configuration of the marginal cost curve of the water utility.

In Louisiana, as indicated previously, water used in industry and agriculture is primarily self-supplied with the exception of irrigation canal companies where the charge is based on a proportion of the rice crop. An appropriate policy for the irrigation canal companies should be based on the marginal cost pricing policy recommended above for water utilities. For self-supplied agricultural and industrial users, the assignement of pro-rata rights or quotas, or use taxes could be imposed on each pumper obtaining water from a common source. The primary aim of either method is to avoid excessive overdraft of water and to assure a rational allocation of the resource among competitive users. The pro-rata method is regarded as most favorable since it is relatively simple and permits the operation of a market mechanism in allocating water by the trading of water rights.

In conclusion, a pricing policy for water resources in Louisiana based on marginal cost of production is centered primarily on the problem of efficient allocation of water resources among its competitive uses. A rational economic allocation of water resources will serve to benefit society as a whole. Marginal cost pricing is recognized to have certain limitations, but these limitations are of a lesser nature than the inherent deficiencies associated with an average cost pricing policy. Similarly, the implementation of pro-rata water rights or a use tax has some economic disadvantages, but the use of either method, particularly the former, can result in a more rational allocation of water among self-supplied agricultural and industrial users. Economic resources such as water should be allocated as efficiently as possible among competitive users so that adequate water supplies can be assured to residents of Louisiana.

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Personal letter from Chief Accountant, Louisiana Public Service Commission. Baton Rouge, Louisiana.

Personal letter from the Supervisor of a Large Metal Industry.

APPENDIX

APPENDIX A

C O N F I D E N T I A L

LOUISIANA AGRICULTURAL EXPERIMENT STATION
LOUISIANA STATE UNIVERSITY
DEPARTMENT OF AGRICULTURAL ECONOMICS AND AGRIBUSINESS
Baton Rouge, Louisiana 70803

LOUISIANA WATER-PRICING SURVEY

No. ______

1. Name of water utility ____

2. Address ____

   (a) Would you like to receive a copy of the research report when completed?

   /__/ Yes   /__/ No

   (b) Type of ownership: /__/ Private   /__/ Public

   (c) What authority regulates your rate schedules?

   /__/ Public Service Commission   /__/ Mayor

   /__/ Council   /__/ None

   /__/ Police Jury   /__/ ____________ (Specify)

3. What communities and population served, by type, in 1971?

Name of community or area	Population served	
	Retail	Wholesale
(1)		
(2)		
(3)		
TOTAL		

4. Please identify sources of water and indicate percent obtained from each source.

________	Lake	____%	________	Spring	____%
________	Bayou	____%	________	Purchased	____%
________	River	____%	________	Other	____%
________	Well	____%		Total	____%

5. Investment: Wells $________ Storage $________ Pumps $________

   Treatment plant $________ Buildings $________

   Distribution lines $________ Total $________

   (a) Total miles of distribution lines ________________

6. Distribution:

   Total gallons produced in 1971 ________________

   Gallons lost ________________

7. Rate Schedules:

   (a) Flat rates $________ per month

   (b) Metered rates $________ per ________ gallons per month

   $________ per ________ gallons per month

   $________ per ________ gallons per month

   $________ per ________ gallons per month

   $________ per ________ gallons per month

   $________ per ________ gallons per month

   (c) Customer deposits ________ ________ ________

   Minimum charge $________________ per month

   Volume of water allowed in the minimum charge ______ gallons

(d) Special charges:

(1) Installation of meters $______ Service lines $______

(2) Tapping fee $______ Reconnection fee $______

(3) Public fire protection charge $______ per year

(4) Private fire protection charge $______ per year

(5) Surcharges: Air-conditioning $______

Sprinkling $______ Other $______

(6) Outside area limits: Charges $______ per 1,000 gallons per month

8. Volume of water by class use and value in 1971:

Class	Gallons	Value
Residential		
Commercial		
Industrial		
Agricultural		
Public		
Retail		
Wholesale		
Total		

9. Non-water sales revenue ______ gallons

Fire hydrants	Number	Rate	Annual Charge
Municipal			
Private			
Total			

10. Please complete the following:

<u>Total Annual Operating Costs</u> (1971)

1. <u>Annual Variable Operating Costs</u>

Maintenance and repairs	$__________
Pumping	$__________
Purification	$__________
Transmission	$__________
Accounting and bill collection	$__________
Administrative	$__________
Miscellaneous	$__________
Subtotal	$__________

2. <u>Annual Fixed Operating Costs</u>

Depreciation	$__________
Interest	$__________
Insurance	$__________
Taxes	$__________
Miscellaneous	$__________
Subtotal	$__________
Total annual operating costs	$__________
Net income or (net loss)	$__________

11. On what cost-basis are service charges developed?

____

____

____

12. How are fire protection rates determined and on what cost-basis?

____

____

____

13. On what cost consideration are special rates determined for air-conditioning, lawn-sprinkling, outside limits, et cetera?

14. What is your major cost consideration or objective in planning current rate schedules?

15. What official(s) is/are mainly responsible for determining the rate structure?

16. Please add any remarks or comments which you consider will be of relevance to this study.

APPENDIX B

Distribution of municipal water utilities by population served

Population served	Number of utilities
1 - 500	5
501 - 1,000	6
1,001 - 3,000	6
3,001 - 5,000	5
5,001 - 10,000	7
10,001 - 15,000	7
15,001 - 25,000	6
25,001 - 50,000	5
Above 50,000	7
	54

VITA

Roopchand Ramgolam was born in Cumberland, Guyana on September 9, 1937. He attended primary school in Cumberland and secondary school at Berbice High School where he gained the General Certificate of Education examination of London University in 1954. In 1962, he entered Inter-American University of Puerto Rico and was graduated in 1964 with the Bachelor of Arts degree (magna cum laude) in Economics and Business Administration. In 1965 he enrolled at the University of Puerto Rico and obtained the Master of Science degree in Agricultural Economics in 1966.

Between 1954 and 1962 he taught in elementary and secondary schools in Guyana. In 1966, he joined the staff of the Water Resources Research Institute of the University of Puerto Rico as an Economist and Assistant to the Director. In 1969, he transferred to the Department of Social Sciences as an Instructor, a position which he currently holds in the Department of Economics. In 1971, he enrolled in the Graduate School of Louisiana State University where he is now a candidate for the degree of Doctor of Philosophy in Agricultural Economics.

EXAMINATION AND THESIS REPORT

Candidate: Roopchand Ramgolam

Major Field: Agricultural Economics

Title of Thesis: The Pricing of Water in Louisiana

Approved:

Floyd L. Corty

Major Professor and Chairman

James G. Traynham

Dean of the Graduate School

EXAMINING COMMITTEE:

Loren C. Scott

Leo J. Guedry

William H. Alexander

J. F. Wiegmann

Date of Examination:

June 18, 1974